

NAVAL POSTGRADUATE SCHOOL

Monterey, California



THESIS

**KNOWLEDGE MANAGEMENT IN NAVAL SEA SYSTEMS
COMMAND: A STRUCTURE FOR PERFORMANCE
DRIVEN KNOWLEDGE MANAGEMENT INITIATIVE**

by

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September 2002

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**KNOWLEDGE MANAGEMENT IN NAVAL SEA SYSTEMS COMMAND: A
STRUCTURE FOR PERFORMANCE DRIVEN KNOWLEDGE MANAGEMENT
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ABSTRACT

Knowledge Management (KM) has been promoted as a method to leverage an enterprise “core competence” to gain an advantage in the market place. The objective is to make the enterprise more competitive and nimble. The ultimate objective of KM is to increase the performance of knowledge-work processes.

This research reports on an in-depth evaluation of a DoD organization and the subsequent process redesign to improve knowledge-management (KM) capabilities at a Naval Sea Systems Command (NAVSEA) field activity. The entity initially targeted for the initiative is the Submarine Electromagnetic Department of NAVSEA Newport, Undersea Warfare Center Division, but the thesis results are expected to generalize to the NAVSEA enterprise as a whole and possibly well beyond the Navy. Strategy is formulated and the processes of the organization are redesigned to enhance performance through KM. An action research method is employed to understand the culture, people, processes and products of the targeted organization in order to design a KM system that fits the entity. The initial goal is to enable the entity to gain a competitive advantage in its areas of excellence with the long-term goal of expanding the KM initiative across the entire NAVSEA enterprise to maximize NAVSEA’s contributions to the fleet.

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TABLE OF CONTENTS

I.	INTRODUCTION.....	1
A.	BACKGROUND.....	1
B.	PURPOSE	3
C.	RESEARCH QUESTIONS	5
D.	BENEFITS OF STUDY	6
E.	SCOPE AND METHODOLOGY.....	7
1.	Scope.....	7
2.	Methodology	7
F.	ORGANIZATION OF STUDY.....	8
II.	LITERATURE REVIEW.....	9
A.	INTRODUCTION.....	9
B.	THE DEPARTMENT OF DEFENSE WORKFORCE	9
C.	KNOWLEDGE MANAGEMENT.....	10
1.	Background.....	11
2.	Knowledge Management Trends	12
3.	KM in the Military Context: Dominant Battle Space Knowledge.....	13
4.	Knowledge Management in the Navy.....	14
D.	KNOWLEDGE MANAGEMENT MODELS	17
1.	Nonaka's Knowledge Spiral	17
2.	The Knowledge-Performance Engine Model.....	18
3.	Nissen's Extended Knowledge-Flow Dynamic Model.....	19
4.	The Department of the Navy Knowledge Management Model.....	20
5.	DSMC Military Fellow Knowledge Management Framework.....	21
E.	INFORMATION TECHNOLOGY	22
F.	ORGANIZATIONAL CONSIDERATIONS.....	24
G.	CHAPTER SUMMARY	26
III.	RESEARCH METHODOLOGY.....	27
A.	INTRODUCTION.....	27
B.	DESCRIPTION OF RESEARCH METHODS.....	28
1.	Researching Knowledge Management Framework and Models ..	28
2.	Reviewing Other Organization's KM Systems	29
3.	Performing Content Analysis	29
4.	Using Contingency Tables	30
5.	Conducting Surveys at the Targeted Organization	31
6.	Doing Interviews.....	31
7.	Observing Participants	32
C.	MAPPING THE RESEARCH METHODS TO KMS DESIGN PHASES	33
D.	CHAPTER SUMMARY	34
IV.	RESEARCH RESULTS	35

A.	INTRODUCTION.....	35
B.	RESULTS FROM THE KMS DISCOVERY PHASE.....	36
1.	Literature Review Results	36
a.	<i>Knowledge Management Models</i>	37
b.	<i>The Navy's Knowledge Management Effort</i>	37
c.	<i>Information Technology for Knowledge Management</i>	40
2.	Survey and Interview Results at the Targeted Organization.....	42
a.	<i>Informal Technical Exchange Seminars</i>	42
b.	<i>Utilization of Information Technology Tools</i>	43
c.	<i>Mentoring and Succession Planning</i>	43
d.	<i>Knowledge Sharing Culture</i>	44
3.	Observations Research Results at the Targeted Organization	44
a.	<i>Observed NUWCDIVNPT Management Initiatives</i>	45
b.	<i>Observed Collaboration and Knowledge Sharing Activities</i>	46
c.	<i>Observed Usage of Information Technologies</i>	47
4.	Other Organizations' Knowledge Management Programs	49
a.	<i>MITRE Corporation</i>	49
b.	<i>Portsmouth Naval Shipyard</i>	52
c.	<i>Knowledge Sharing in an Operational Arena</i>	58
5.	Content Analysis Results of the Employee Opinion Survey.....	59
6.	Statistical Analysis Results of a Study on IPT	63
7.	KM Requirements for the Targeted Organization	64
C.	KNOWLEDGE MANAGEMENT SYSTEM PROTOTYPING PHASE.....	65
1.	Prototypes for the People Pillar	66
a.	<i>Changing the Culture</i>	66
b.	<i>Incorporating Knowledge Sharing into the Performance Review</i>	67
2.	Prototypes for the Process Pillar.....	68
a.	<i>Expanding the Scope of the Technology Council</i>	68
b.	<i>Sharing Explicit Knowledge</i>	68
c.	<i>Supporting Technical Exchanges</i>	69
3.	Prototypes for the Technology Pillar.....	71
a.	<i>Creating Knowledge Map</i>	71
b.	<i>Managing Technical Information</i>	71
c.	<i>Participating in Electronic Bulletin Board</i>	72
4.	Preliminary Results from the Prototyping Phase.....	72
D.	KNOWLEDGE MANAGEMENT SYSTEM DESIGN PHASE	74
1.	Knowledge Management Design Considerations	74
2.	Proposed Knowledge Management Design.....	75
a.	<i>People Dimension Design</i>	76
b.	<i>Process Dimension Design</i>	78
c.	<i>Technology Dimension Design</i>	81
3.	Performance Metrics for the Proposed Design.....	82

E.	CHAPTER SUMMARY	83
V.	IMPLEMENTATION.....	85
A.	INTRODUCTION.....	85
B.	IMPLEMENTATION CONISDERATIONS	85
1.	Strategic Goals and Leadership Vision	85
2.	Implementation Plan.....	86
a.	<i>Implementation Team</i>	86
b.	<i>Redesign and Implement Organizational Processes</i>	87
c.	<i>Pilot KM Projects</i>	88
d.	<i>Technology Selection</i>	89
e.	<i>Project Management</i>	89
3.	Capability Maturity Measures.....	89
C.	SUMMARY.....	91
VI.	CONCLUSIONS AND RECOMMENDATIONS.....	93
A.	CONCLUSIONS.....	93
B.	RECOMMENDATIONS FOR THE TARGETED ORGANIZATION ..	94
C.	RECOMMENDATIONS FOR FUTURE RESEARCH.....	95
1.	Design Survey	95
2.	Design a Knowledge Management Awareness Program	95
3.	Link the Knowledge Flow with Organizational Performance	96
4.	Define Supply and Demand Function for Knowledge Sharing.....	96
5.	Measure the Performance Metrics	96
APPENDIX A.	STATISTICAL ANALYSIS OF AN IPT SURVEY	97
A.	INTRODUCTION.....	97
B.	DESCRIPTION OF SURVEY	97
C.	STATISTICAL ANALYSIS.....	99
1.	IPT Implementation and Assessment Between NAVSEA and NAVAIR.....	101
2.	Assessment of IPTs from the Political and Cultural Perspectives.....	104
3.	Assessment of IPTs as a Function of Team Experience.....	106
D.	SUMMARY OF ANALYSIS RESULTS.....	109
APPENDIX B.	SURVEY QUESTIONS USED TO ASSESS THE TARGETED ORGANIZATION'S KNOWLEDGE MANAGEMENT STATUS	111
	LIST OF REFERENCES	113
	INITIAL DISTRIBUTION LIST	119

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LIST OF FIGURES

Figure 1.	Accessibility of Shared Information [from Ref. 7]	3
Figure 2.	The Spectrum of Information and Knowledge [from Ref. 39]	11
Figure 3.	NAVSEA Distance Support Portal [from Ref. 39]	16
Figure 4.	The Tacit-Explicit Knowledge Cycle [from Ref. 45]	18
Figure 5.	The Dynamic Alignment of Knowledge Engine [after Ref. 8]	19
Figure 6.	The Department of the Navy Knowledge Management Framework [from Ref. 37]	21
Figure 7.	Knowledge Management Framework [after Ref. 6]	22
Figure 8.	NUWC University Offerings	46
Figure 9.	Targeted Organization's Technical Briefs and Presentations Page	48
Figure 10.	Submarine Factory Program Homepage	56
Figure 11.	Portsmouth Naval Shipyard Project Management Homepage	57
Figure 12.	Up-to-Date Brown Bag Seminar Schedule	73
Figure 13.	Three Dimensions of the Proposed Knowledge Management System	76
Figure 14.	People Dimension of the Knowledge Management System	77
Figure 15.	Process Dimension of the Knowledge Management System	79
Figure 16.	Technology Dimension of the Knowledge Management System	81
Figure 17.	Implications of Advancing Through the Capability Maturity Model [from Ref. 74]	90
Figure 18.	Survey Form Used for the PD-21 Excellency in IPT Study [from Ref. 60] ...	98

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LIST OF TABLES

Table 1.	Mapping Research Methods to KMS Developmental Phases.....	33
Table 2.	Positive and Negative Comments About Own Organization.....	60
Table 3.	Facilitators and Obstacles to Implementing KM.....	61
Table 4.	Enablers for Knowledge Management Implementation.....	62
Table 5.	People Dimension Design and Knowledge Sharing Reasons	77
Table 6.	Tasking for People Dimension Design Sub-Elements	78
Table 7.	Tasking for Process Dimension Design Sub-Elements.....	80
Table 8.	Knowledge Management Performance Metrics [after Ref. 37]	82
Table 9.	Personal IPT Assessment	101
Table 10.	Interviewee's assessment of his/her organization's IPTs	101
Table 11.	Interviewee's assessment of his/her organization's IPT usage	102
Table 12.	Interviewee's assessment of his/her organization's acceptance of IPT.....	102
Table 13.	Awareness of Team Building Guide	103
Table 14.	Awareness of IPT training.....	103
Table 15.	Interviewee's assessment of his/her organization's IPTs	104
Table 16.	Interviewee's assessment of his/her organization's acceptance of IPTs	104
Table 17.	Interviewee's awareness of his/her organization's guide to IPT.....	105
Table 18.	Interviewee's awareness of his/her organization's IPT training	105
Table 19.	Personal IPT Assessment	106
Table 20.	Personal IPT Assessment	106
Table 21.	Assessment of own IPT Success by experience.....	107
Table 22.	Assessment of own IPT Success by work type	107
Table 23.	Combined assessment of own IPT success	108
Table 24.	Personal Assessment on IPT by Work Types	108
Table 25.	Interviewee's assessment of his/her organization's IPT usage	109
Table 26.	Questions for KM Specific Survey	111

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I. INTRODUCTION

A. BACKGROUND

The fast pace of system development using Commercial Off-the-Shelf (COTS) equipment and commercial standards has forced the Department of Defense (DoD) acquisition management community to re-examine the way it does business in order to remain relevant. Many management initiatives have been kicked off to adapt to this revolutionary change. The Integrated Product Team (IPT) is one concept that appears to have been integrated into the fabric of the DoD acquisition community [Ref. 1, 2]. The IPT concept is centered on cross-functional teams and participatory decision-making. Many programs have reported successes although the General Accounting Office (GAO) has identified some lessons learned in real life IPTs [Ref. 3].

The Navy Sea Systems Command (NAVSEASYS COM) is the largest DoD acquisition management command with over 50,000 personnel and an annual budget of over \$20 billion. It has 36 major shore facilities and 200 field activities spread across the continental US and overseas [Ref. 4, 5]. The technical personnel at NAVSEA are assigned to direct reporting Program Executive Offices (PEO) or program management offices (PMS) at its headquarters at the Washington Navy Yard, or to shore facilities/field activities. In the performance of their duties they typically seek data, information and knowledge within the sphere of immediate contacts. Only very seldom do they seek expert help outside this sphere [Ref. 6]. The expected return on time investment for an individual to seek knowledge outside usually does not justify the effort. These closed communities inadvertently create stovepipes and hinder the utilization of the collective knowledge of the entire organization to solve problems, problems that might have already been solved innovatively by an individual or group on the next floor. Although desirable for task-oriented teams, locating personnel in close proximity does not guarantee knowledge sharing if no sharing infrastructure exists. We know intuitively that if we could capture even a fraction of that collective knowledge dispersed across the entire enterprise the performance of the entire organization could be improved tremendously.

While the DoD research and development personnel are encouraged to maximize the leveraging of the entire R&D talent pool to solve problems, many do not know where to start. The "I don't know what I don't know" syndrome prevails. Knowledge Management (KM) is the latest initiative that has received executive level attention in many DoD organizations. Knowledge Management may be defined as the effective utilization of the collective experience and wisdom across an enterprise to enhance responsiveness and product quality. The hierarchy of data, information, and knowledge may be described as follows: data is the quantifiable numbers and facts without context (e.g., individual measurements), information is data put into context (e.g., graphing the individual measurements to identify trend), and knowledge is the synthesis of information, intuition, and experience to effect a decision or action. [Ref. 4, 6, 7]

In the 1960's, the enterprise's data and information resided in main-frame computers with access privileges restricted to a few specialists. The accessibility of shared data and information has improved exponentially with the advent of the personal computer and more recently, the INTERNET. It is well accepted that efficient data and information access is enabled by information technology (see Figure 1). Private and public organizations have implemented software applications known as knowledge portals to disseminate personnel, project, and technical information and to establish people-to-people connections. Many knowledge portals are well received by their users. Some notable enterprise-wide knowledge portals that have been deployed are: IBM, Xerox, Hewlett Packard Consulting, Chevron, MITRE, U.S. Army, Andersen Consulting, British Petroleum, and Ford Motor Company [Ref. 8-10]. Many researchers assert that tacit knowledge (intuition, experience and wisdom) resides in the heads of people [Ref. 6-10], not in computer servers containing files and databases. One of the major challenges of KM is the capturing of the organization's tacit knowledge [Ref. 6, 8-10].

Knowledge Management, if designed and implemented correctly, can support the many tactical and strategic decisions required in DoD acquisition management functions. The leadership from top management is necessary to emphasize the importance of KM to the organization's competitiveness. However, delegation of design and implementation details to the user community is essential for ensuring grass roots support of this major cultural and process change. The reliance on top down directives from management to

implement Knowledge Management is usually not the best approach to get people passionately involved in the knowledge management cycle [Ref. 9, 10]. Without this involvement from the user segment, experience suggests KM will deteriorate into another management fad subject to apathy, if not ridicule. The successful design of a KM system must take into account the organization's culture, core competencies, technologies, and processes [Ref. 3, 6, 10]. The bottom up design approach seeks to involve the participants of KM from the beginning in order to establish a sense of shared ownership. A KM portal is useless if few people visit the site; an 'empty store' without useful information will not attract visitors. Information Technology (IT) is an enabler but it is not knowledge management by itself.

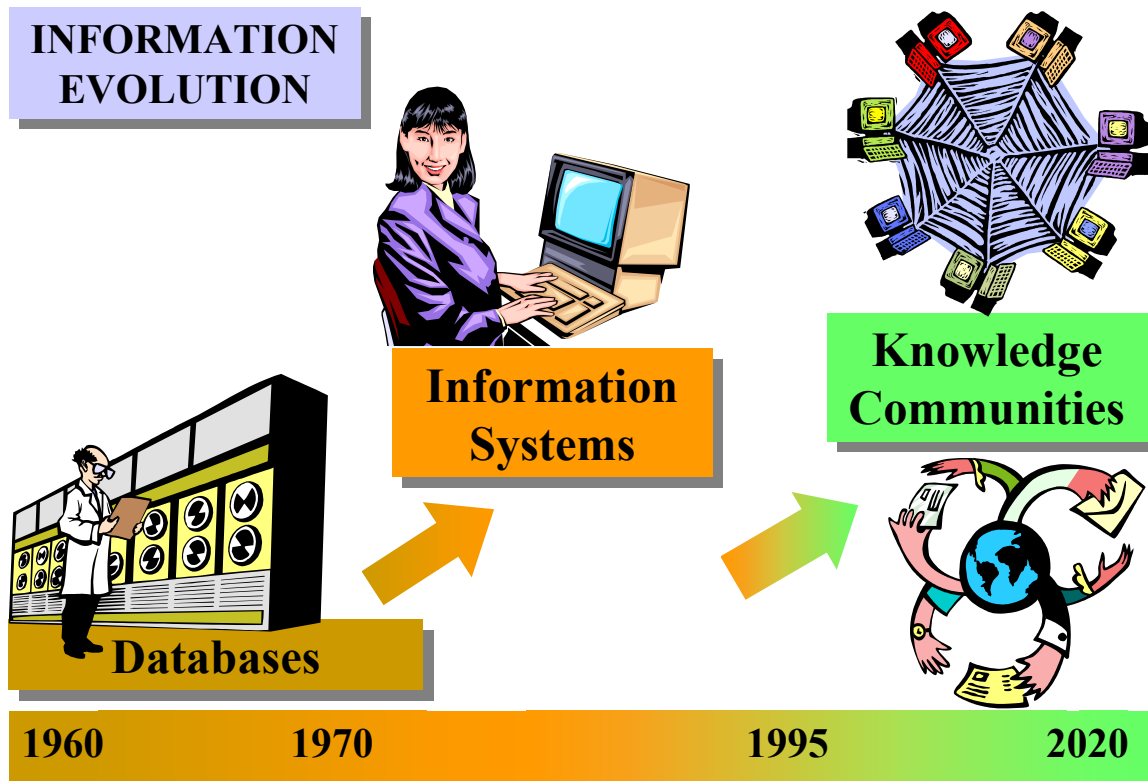


Figure 1. Accessibility of Shared Information [from Ref. 7]

B. PURPOSE

The purpose of this thesis is to design a pilot KM System (KMS) to support innovative research and development activities at a 200-person organization. The Submarine Electromagnetic Department (Code 34) is a federal Research, Development,

Test and Evaluation (RDT&E) organization headed by a Senior Executive Service (SES) with an annual budget of \$120M. It is one of the seven major departments at the Naval Undersea Warfare Center Division Newport, RI (NUWCDIVNPT). NUWCDIVNPT is a major shore facility of NAVSEASYS COM with over 2700 employees (of which 1900 are technical staff members) and an annual operating budget of \$670M. Since it is a Navy Working Capital Fund (NWCF) organization, NUWCDIVNPT must compete for work against private industries, universities, and other government funded laboratories. The competition has become fierce due to the reduction in RDT&E funding across the board. NUWCDIVNPT recognizes that knowledge management is necessary to maintain its core competencies in the environment of downsizing and reduced resources in order to remain competitive. [Ref. 12]

The need for KM has become acutely evident after the Base Realignment and Closure (BRAC) when the job functions of four departments were transferred from New London, CT to Newport, RI in late 1995. The Submarine Electromagnetic department, along with the other affected departments, experienced significant attrition due to early retirements and resignations. Senior personnel with tacit knowledge left the organization without proper turnover. Many employees who just entered the journeyman rank resigned to take advantage of the opportunities in the private sector during the mid-nineties. The exodus essentially halted the department's normal knowledge flow because these fully qualified employees were no longer available to mentor the new hires. The department has been able to retain some of that knowledge by contracting the former employees to perform their old jobs. However, this is a short-term solution because the contractors do not mentor the government employees. Obviously, a more proactive approach is necessary to maintain the core competencies of the department for it to compete effectively.

The proposed KMS design approach for the department is a 'bottom up' design where the knowledge holders and seekers are involved in the entire process. The goal is to design a scalable KMS such that the pilot program may be used as a template to propagate KM throughout the entire NAVSEA organization. The desired end goal is a fully netted DoD acquisition management system that continually leverages the knowledge of the entire NAVSEASYS COM organization to enable its people to deliver

quality services and products to the fleet. The current INTRANET/INTERNET portals across the NAVSEA organization are not utilized fully to implement enterprise wide knowledge management. Many of the web pages contain obsolete information and time sensitive contents are not updated consistently. More importantly, there is little content that could be classified as elements of knowledge management. The current system is, in reality, a data warehouse on its way to being a data junkyard. The top down approach, usually accompanied by much top management fanfare at kickoff, often does not take into account the needs of the users in terms of content, interface, accessibility, and perceived benefits.

The purpose of this pilot KM initiative is to demonstrate the utility of knowledge management to create a cadre of believers who will become 'evangelists' to propagate the KMS across the enterprise. The results of this effort will be used to enhance the development of KMS.

C. RESEARCH QUESTIONS

Many KM efforts have started with great fanfare only to fizzle out after a year or two. What is the design approach that will allow KM to self sustain?

Primary research question: How should an organization's knowledge management system be designed to leverage its core competencies to enhance its performance?

Secondary research questions:

- What are the critical internal and external issues driving the Knowledge Management initiative? What is the desired state that the KM initiative is expected to attain?
- What is NAVSEA's strategic business plan? What is the optimal Knowledge Management life cycle model to map KM to the organization's strategic plan? What would be an optimal model for the Submarine Electromagnetic Department's KM initiative considering its culture, people, processes and products?
- What is the current knowledge and information flow? What are the improvements required to realize the desired state.
- What are the enablers and obstacles that affect the effectiveness of KM? How does the design leverage the enablers and de-emphasize the obstacles?

- What should the scope of the KM pilot project be to demonstrate efficacy? What are the performance metrics (expected benefits) to measure the success of the KM pilot project?

The American Productivity and Quality Council (APQC) has developed a roadmap for knowledge management initiative which includes the following milestones: define the objective of the initiative, evaluate the current state of information and knowledge sharing activities, analyze the gap between desired state and the current state, devise actions (process changes and personnel realignment), and identify tools (Information Technology investments) to attain the KM objectives. The final milestone of the roadmap is the definition of the performance metrics to evaluate the progress of the initiative [Ref. 13]. The design of a KMS requires an understanding of the knowledge life cycle (from create to evolve), the nature of knowledge (from tacit to explicit), the reach (from one to thousands of users), and the duration (from hours to years). A framework to capture this multi-dimensional feature space systematically is necessary to guide the system development [Ref. 14, 15].

D. BENEFITS OF STUDY

Knowledge Management (KM) has been promoted as a method to capture an enterprise's "core competencies". The objective of KM is to make the enterprise more competitive and nimble. Core competencies, rather than core products, are the enduring differentiators to separate the successful companies from the also-rans [Ref. 10, 16-20]. The ultimate objective of KM is the delivery of the right knowledge, generated by the KM life cycle, to the right person just in time such that decisions can be made more responsively to improve the organization's performance. Reduction of cycle time is an important metric for any business; similarly, the ability of the military commander to reach decisions quicker will decide the outcome of battles [Ref. 21, 22]. The accepted quantitative measures for a KMS are better response time, high quality deliverables, more comprehensive analyses/reports, and higher morale due to increased pride in one's organization.

E. SCOPE AND METHODOLOGY

The scope and methodology for this research are outlined in this section. The end goal of this research is to define the KM needs of a targeted organization (the subject of the pilot project), design the optimal infrastructure (people, technology, and processes [Ref. 6]), and identify implementation considerations.

1. Scope

The scope of this thesis includes the following:

- A review of current KM efforts in organizations with similar functions.
- A review of KM models.
- A survey of the current knowledge and information flow processes at the targeted organization, the Naval Undersea Warfare Center Division Newport's Electromagnetic Department. This includes an in-depth analysis of the organization's culture, people, processes, and products to plan a KM initiative.
- A knowledge management strategy for the targeted organization.
- A KM architecture design and KM life cycle to launch the organization's KM initiative.

Performance metrics are defined to measure the KM program's efficacy in order to effect closed loop control of the program.

2. Methodology

The methodology used in this thesis research consists of three phases. They are the discovery, prototyping, and design phases.

In discovery phase, the targeted organization's culture, people, processes, and technology are analyzed. The organization's knowledge sharing practices and the tools currently in use to capture/create, organize, formalize, distribute, and apply knowledge are also examined. The data collection consists of surveys, selected interviews, and direct observations to understand the dynamics of knowledge flow in these organizations. In addition, two other organizations having similar work functions are evaluated to gather information on their best practices, lessons learned, and potential pitfalls.

The efficacy of various personnel initiatives, KM tools, and processes are evaluated in the prototyping phase. User feedback and comments are collected and categorized to support the KMS design phase.

The goal of the design phase is to design an optimal knowledge management system for the targeted organization. The results from the preceding phases are used to support this design.

F. ORGANIZATION OF STUDY

This study consists of six chapters, covering the background of KM, literature review, research methodology, KMS design, summary, and recommendations for future work.

Chapter I provides a brief introduction and summary of this thesis. Chapter II consists of a review on the body of KM research literature. The scope of the review includes KM theories, KM models, information technologies, views from the process, people, and technology angles, and on-going KM programs in government and industry. Chapter III describes the research methodology used for this research. Several research methods, both qualitative and quantitative, are used for the development of this thesis.

Chapter IV is the core of this thesis. It describes the detailed results of the discovery, prototyping, and design phases for a Knowledge Management System. This chapter explains the steps in analyzing the knowledge flow process at the targeted organization and the obstacles to overcome to allow a KM culture to take root. It provides a design of a KMS based on the analysis of the results from the planning and discovery and prototyping phases. Chapter V contains a proposed implementation of a KMS for the targeted organization with suggested feedback and monitoring mechanisms. Finally, Chapter VI summarizes this research and provides lessons learned. It also contains recommendations for future research.

II. LITERATURE REVIEW

A. INTRODUCTION

The Knowledge Management (KM) concept has experienced a remarkable increase in popularity among corporations and government agencies. Many organizations have committed significant resources to create KM systems in order to enhance the knowledge and work flow of their employees. The theoretical investigations of KM, its relationships to other technical endeavors and management theories, knowledge flow models, and organizational interactions are likewise increasing exponentially [Ref. 14-20, 23-25]. The number of KM conferences, training classes, symposia, and trade shows has proliferated; many organizations are hiring consultants to help with the design and implementation of KM [Ref. 26-31]. The relentless pursuit of KM stems from the rapid flattening of corporate structure that is depleting the collective knowledge base through downsizing. Significant loss of core competencies will likely occur should key persons depart due to voluntary or involuntary personnel actions. Both the private and public sectors embrace the concept of KM, although there are many different interpretations of what KM really entails. [Ref. 31-34]

The literature review chapter assesses the current state of the major factors affecting knowledge management. The Department of Defense (DoD) workforce, knowledge management, KM models, information technology, and organizational considerations are the key factors driving the design and implementation of a successful knowledge management system.

B. THE DEPARTMENT OF DEFENSE WORKFORCE

The DoD workforce is undergoing re-engineering to improve the cost, schedule, and performance of its wide spectrum of activities. Much of the DoD workforce is close to retirement age; the average age of DoD workers is 46 years old (close to 50 in industrial facilities such as shipyards and weapons depots) and this creates an emergent issue of seamless succession. The last of the defined-benefit Civil Service Retirement System (CSRS) employees will retire by 2010. The Federal Employee Retirement

System (FERS) employees have much more flexibility and are expected to exercise that option when the economics of employment favor the private sector [Ref. 35, 36]. This potential loss of tacit knowledge has reached a crisis level for some activities in the ship repair and advanced technology occupations [Ref. 6, 12, 35]. Significant knowledge and cultural gaps exist between veterans and the current hires due to hiring freezes and hiring frenzies during the past 20 years [Ref. 12, 36]. The National Academy of Public Administration Center for Human Resources Management report states that human capital is essential to the future effectiveness of U.S. Naval Force [Ref. 35]. There is consensus among federal managers that the human resource system must be re-engineered to recruit and retain knowledgeable employees [Ref. 4, 35].

Naval Undersea Warfare Center Division Newport is a major shore facility of NAVSEASYS COM. The demographics of the (NUWC) workforce mirror that of the DoD workforce [Ref. 12]. The recruiting sources are clustered across the New England states with the highest concentration from the southeastern part of the region. The high cost of living in New England discourages many candidates from other regions from accepting federal appointments with NUWC [Ref. 36]. As was pointed out in Chapter I, the BRAC actions in 1995-1997 resulted in substantial loss of core competencies.

C. KNOWLEDGE MANAGEMENT

Knowledge management has replaced Business Process Re-engineering (BPR) as the latest management hot item. What can KM do for an organization that Total Quality Management (TQM) or BPR cannot do? The Gartner Group reports that enterprises that lack ongoing KM infrastructure will lag KM-enabled competitors by 30-40% in speed of deployment for new competitive programs and products [Ref. 37]. A GAO report concluded that knowledge and decision authority are the key elements for successful IPTs [Ref. 3]. The amount of information related to KM is overwhelming; this section attempts to summarize how KM relates to DoD missions.

The scholarly literature, popular press, government/corporate websites, and sponsored studies are filled with writings on knowledge management [Ref. 6-10, 13-20, 23-31, 37, 39]. The first subsection addresses the background and some of the history of

knowledge management. The second subsection surveys the KM trends in various public and private enterprises. The third subsection provides an overview of knowledge management in the military operations context. The fourth and final subsection reviews the state of KM in the Navy acquisition functional areas.

1. Background

Knowledge is complex, unlike data and information that can be stored in repositories, sorted, organized, and ready for retrieval. Michael Polanyi was the first to classify knowledge into two categories: tacit and explicit [Ref. 38]. This classification provided a framework to understand the interaction between knowledge creation and knowledge flow. The optimal mix of tacit and explicit knowledge is different from one organization to another, depending upon its functions. Figure 2 shows the spectrum of data, information, and knowledge that may be handled by a knowledge management system. It spans from web-enabled information to a full-fledged knowledge portal.

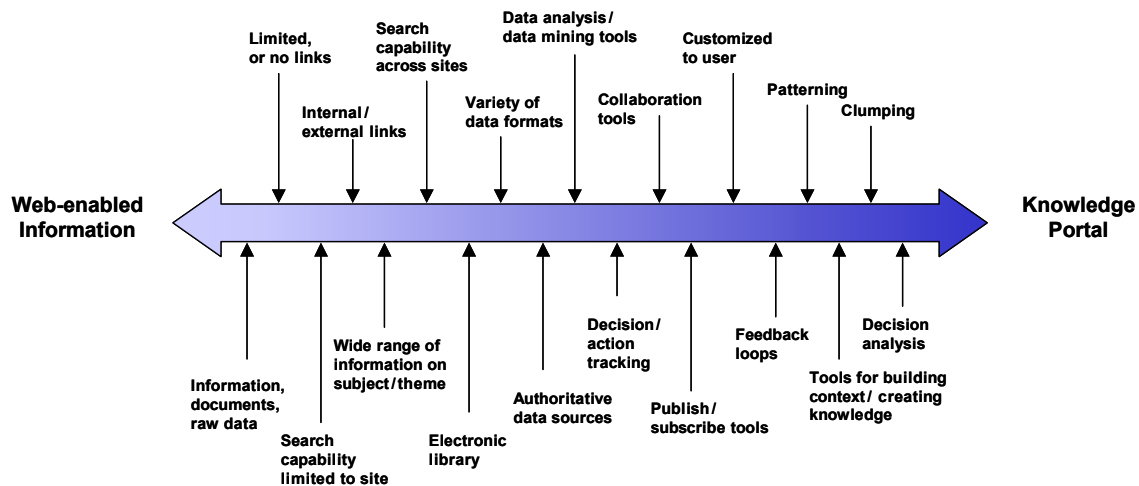


Figure 2. The Spectrum of Information and Knowledge [from Ref. 39]

Professor Peter Drucker asserts that the knowledge of the organization is the key resource, and the only scarce one. He further states that the emerging knowledge society and knowledge economy would be radically different from the society and economy of

the late 20th century. The knowledge workers are the new capitalists because they collectively own the means of production. [Ref. 40, 41]

Formal schooling equips one with adequate knowledge to enter the workforce. But knowledge is time and context sensitive and becomes obsolete rapidly. Thus, knowledge workers must engage in continuing education to remain competitive. [Ref. 41]

Knowledge is touted as the most important intellectual capital asset in today's organizations. A knowledge asset is created when the know-how or experience of individuals can be used by someone other than those involved in its creation. Such an asset can be systematically redeployed in a way that continually creates value [Ref. 16].

One of the critical tasks in knowledge management is the knowledge audit. A knowledge audit consists of business needs assessment, cultural assessment, and an examination of what knowledge is needed, available, missing, applied, and contained. In the same manner that a manufacturing company will first inventory its physical assets, an aspiring "knowledge organization" should also inventory its intellectual capital assets. [Ref. 31, 42]

2. Knowledge Management Trends

An International Data Corporation (IDC) study estimates that by the year 2002 spending on KM consulting services will reach \$3.4 billion in the United States alone. The conference board's year 2000 survey of 200 large companies found that 82% have KM underway and 50% have KM staff and budget [Ref. 37].

The popular press has jumped on the knowledge management bandwagon; a search of books on AMAZON.com will illustrate the popularity of the subject. Many management books have appeared in real and virtual bookstores touting the virtues of KM [Ref. 8, 19, 20, 43-45]. The INTERNET is full of knowledge management consultants offering insight on creating knowledge management systems, conducting knowledge audits, and similar consulting services. Expensive specialty KM software applications have flooded the market place [Ref. 23, 26, 30, 31, 46].

In DoD small efforts are underway to do a better job of sharing knowledge. These efforts are primarily focused on methods, e.g., file repositories of best practices databases and lessons learned. They do not address the most difficult but fundamental barrier, that is, our culture. Our culture is not averse to sharing knowledge, but it does not strongly support and reward sharing [Ref. 6, 11]. However, the human and social factors in knowledge management are beginning to be addressed. [Ref. 47]

The Department of the Navy's Acquisition Reform Knowledge Management Team identified, through a Rapid Improvement Team Process held in February 2001, the need to focus on capturing and building knowledge in core program management areas. The team has created a Program Management Community of Practice, with sub-communities in risk management, contracting, earned value management, software, and systems engineering. [Ref. 48]

3. KM in the Military Context: Dominant Battle Space Knowledge

Military operations demand KM too. It is with an eye on the emerging battlespace that *Joint Vision 2020* emphasizes the importance of information superiority. Sustaining the responsive, high quality, data processing and information needed for joint military operations will require more than just an edge over an adversary. The joint military services must have information superiority, that is, the capability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same. [Ref. 21, 49-51]

Admiral William A. Owens, former Vice Chairman of the Joint Chiefs of Staff, has written:

“What is happening, driven in part by broad conceptual architectures, in part by serendipity, is the creation of a new system of systems. Merging our increasing capacity to gather real-time, all weather information continuously with our increasing capacity to process and make sense of this voluminous data builds the realm of dominant battlespace knowledge (DBK). DBK involves everything from automated target recognition to knowledge of an opponent's operational scheme and the networks relied on to pursue that scheme. The result will be an increasing gap between U.S. military forces and any opponent in awareness and understanding of

everything of military significance in any arena in which we may be engaged." [Ref. 49]

What Admiral Owens calls the system of systems allows a commander to "see" across the breadth of a theater-level operation or into the depth of a complicated Military Operation Other Than War (MOOTW). The goal of this breadth and depth of vision is to "increasingly assign the right mission to the right force, matching our forces to the most successful course of action at both the tactical and operational levels of warfare." The Admiral continues:

"We will know the effects of our actions – and understand what those effects mean – with far more fidelity, far earlier than anything we have experienced to date. This dominant knowledge, in turn, will make any subsequent actions we undertake even more effective, because we will truly be able to operate within the opponent's decision cycle, and the opponent's capacity to operate at all will have been greatly eroded." [Ref. 49]

The U.S. military has undergone a major revolution. For decades, the tribal warfare among the services to secure resources hindered any real interoperability. The lessons learned (e.g., incompatible radios, air tasking orders, separate logistics, ...etc.) in Grenada, Panama, and the Gulf War propelled the military to embrace jointness. Why does it work? It works because an officer's promotion depends on his full acceptance of the new culture of jointness. Thus, the reward system must change to change the culture.

4. Knowledge Management in the Navy

The Navy's corporate knowledge management "czar" is the Department of the Navy Chief Information Officer (DON-CIO). The CIO's Information Management and Information Technology (IM/IT) Vision for the future is:

- An integrated, results-oriented Navy and Marine Corps team characterized by strategic leadership, ubiquitous communication, and invisible technology.
- An effective, flexible and sustainable DON enterprise-wide information and technology environment that enables our people to make and implement efficient and agile decisions.

- A knowledge-centric culture where trust and respect facilitate information sharing and organizational learning. [Ref. 37]

NAVSEA has embraced information technology to improve response time and performance. The Commander of Naval Sea Systems Command, Vice Admiral G. P. Nanos Jr., said in an interview with Jane's Navy International that

"Every NAVSEA commander comes in with a relatively limited term, so when you really want to implement change and modernization you have to be very focused on how you do it. So we created something called the 'Critical Few' that we wanted to generate a sense of urgency for - seven or eight items that I think require continual attention." [Ref. 52].

One of the critical few items is Distance Support (DS), it is a web-enabled process to support the fleet by leveraging the resources of the entire NAVSEA Corporation. VADM Nanos asserted that fleet readiness, logistics support and daily maintenance planning processes continued to improve in 2001 with a more robust, remotely connected Navy Distance Support (DS) and its Anchor Desk Program. For example, during 2001 deployment, the USS Abraham Lincoln Battle Group used DS more than 1600 times, reducing the mean time for equipment repair by 30%. DS is currently installed and fully functional aboard four battle groups and various shore support activities. It is used to conduct daily collaborative maintenance and logistics meetings among deployed battle group commands, type commander staffs, support providers and the Navy Integrated Call Center. In recognition of these successful efforts, DS was presented the Department of the Navy 2001 e-Government Award for Outstanding Warfighter Support. NAVSEA also was selected to lead a Joint Service Advance Concept Technology Demonstration (ACTD) to implement Distance Support DoD-wide. [Ref. 5, 52]

Inaugurated in August 1999, DS had two key objectives: leverage technology to provide the Fleet with access to difficult-to-locate technical and logistics information, and establish the structure and business process for a collaborative infrastructure and shared data environment [Ref. 5]. To support these objectives, a 24/7/365 help desk (1-877-41-TOUCH) was established through a collaborative agreement among the Navy's Systems Commands and Fleet Commanders. The help desk is staffed by very knowledgeable people, active duty and retired Navy chiefs with in-depth institutional knowledge. The

success of the DS is due primary to the quality of the people manning the help desk.
[Ref. 5]

DS was web-enabled (www.anchordesk.navy.mil) in its second year using e-business processes, Tele-Tools, collaboration, and access to a wide spectrum of government and industry data and support services. DS is a key ingredient in implementing a fully functioning maintenance Enterprise Resource Planning (ERP) program. When fully integrated, the Distance Support program will provide the warfighters a single point of entry and process for all administrative, technical, logistics, and personal support, allowing them to concentrate on their primary mission to train, operate, and fight. The DS portal is shown in Figure 3; the objective of the web-enabled DS is "shared data environment facilitating streamlined fleet support processes". [Ref. 5]

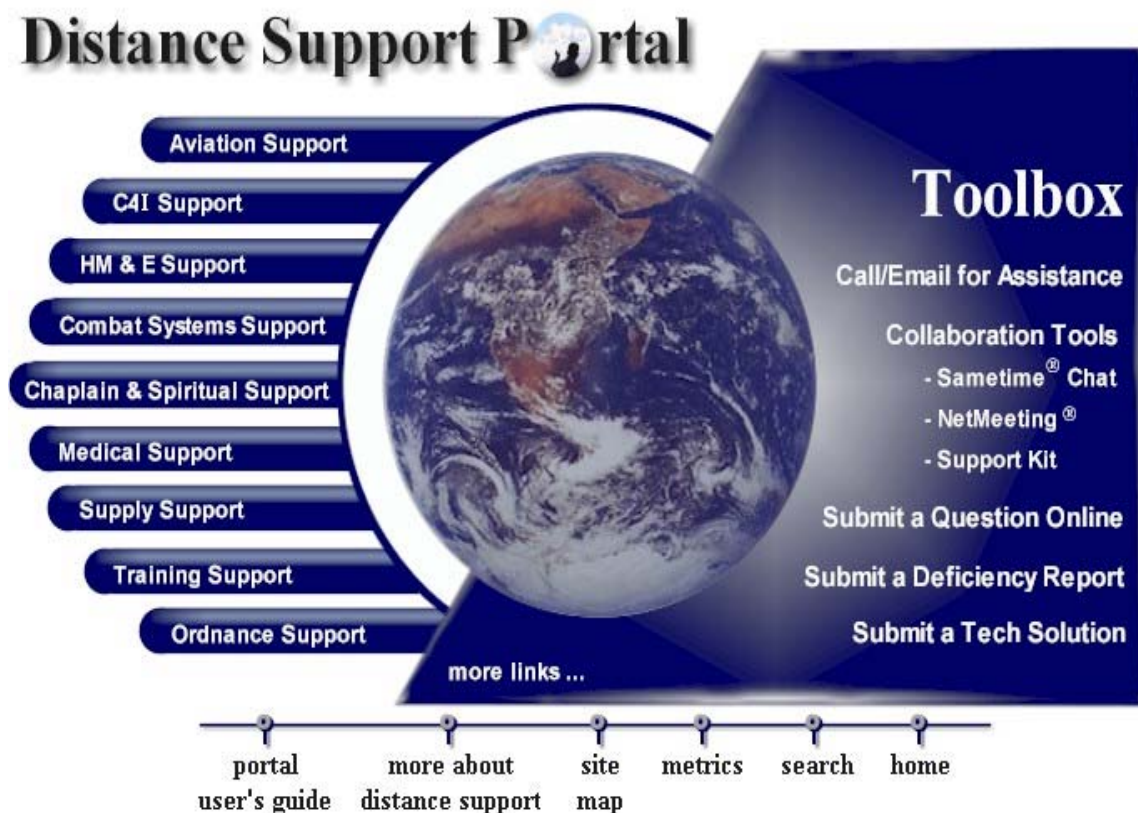


Figure 3. NAVSEA Distance Support Portal [from Ref. 39]

D. KNOWLEDGE MANAGEMENT MODELS

KMS development is complicated. We employ models to reduce the complexity to a manageable level. A model is an abstraction of reality that captures the essential elements of system so that the complexity may be comprehensible to the system designers. A model is a communication tool; it is necessary to articulate the KM objectives and requirements to all the players using abstraction. Some notable models are described briefly in this section.

1. Nonaka's Knowledge Spiral

Nonaka's knowledge spiral models the continuous conversions between explicit and tacit knowledge in an organization. There are four knowledge flows (conversions or transformations) described by the Nonaka knowledge spiral. Socialization is the knowledge transfer from tacit to tacit. This is the person-to-person interaction, e.g., on-the-job training, apprenticeship, and mentorship. Externalization is the transfer from tacit to explicit. This conversion makes use of stories, metaphors, and analogies to convert tacit knowledge into an understandable form. Dialog is an important method for externalization. Combination is the explicit to explicit transfer. Figure 4 shows the knowledge transformation cycle. The efficiency of this transfer has been greatly enhanced by advanced information technology. Finally, internalization is the personal conversion of explicit knowledge into tacit knowledge - the "I've got it" or "Eureka" moment. [Ref. 18, 45]

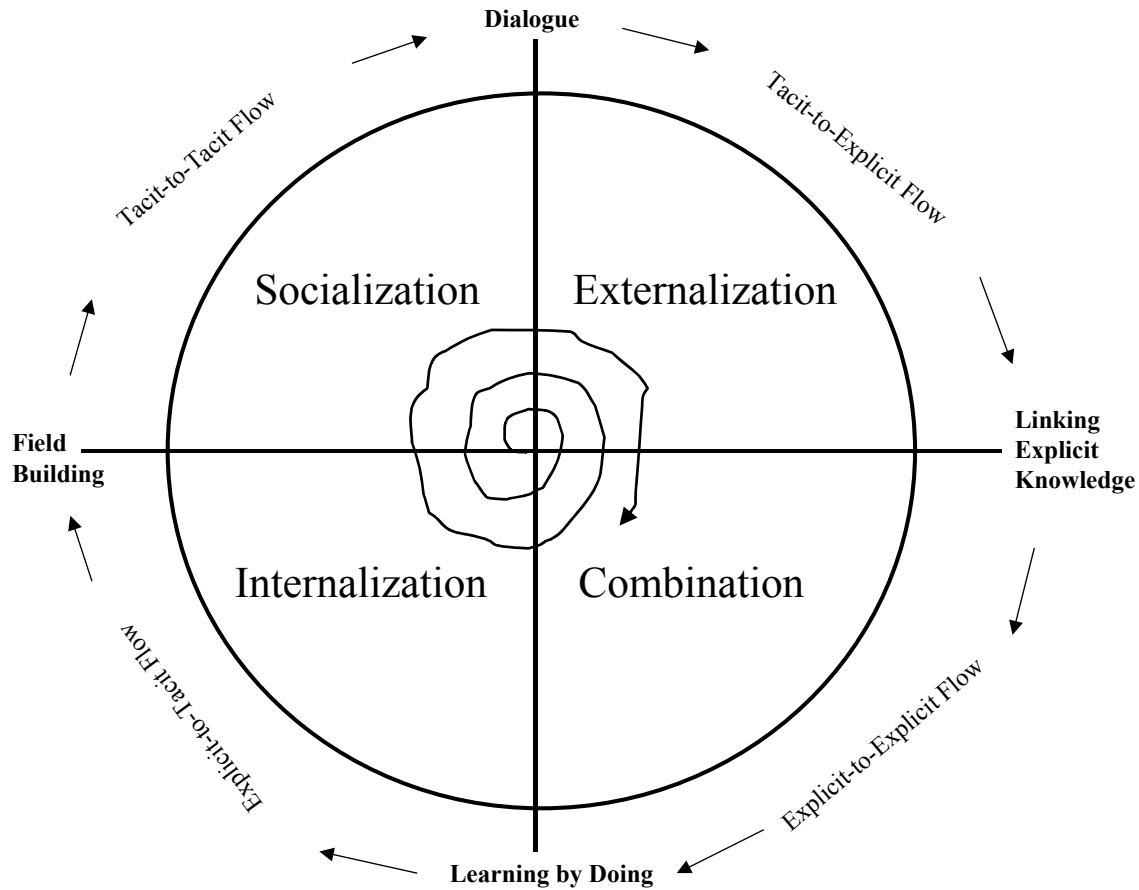


Figure 4. The Tacit-Explicit Knowledge Cycle [from Ref. 45]

2. The Knowledge-Performance Engine Model

The idea of a cycle is a recurring theme in many of the models. Since knowledge is not static, it follows that knowledge management is a dynamic, continuous process. The modern organization cannot stop learning; it must become a learning organization to be competitive. Baird and Henderson propose the two-cycle "knowledge engine" model that would both create knowledge assets and use them to drive performance. In short, performance drives knowledge and knowledge drives performance [Ref. 8].

The "knowledge engine" is sustained by the alignment of strategy and execution. Baird and Henderson assert that strategy must guide execution and set up the conditions for learning, and execution must produce results and capture learning that informs strategy. The two cycles feed off each other to power a learning engine. [Ref. 8]

In dynamic control system terminology, the production capability is the plant and the strategic capability is the control system. The two parts are connected by feedback and control loops. The dynamic alignment model of the knowledge engine is shown in Figure 5.

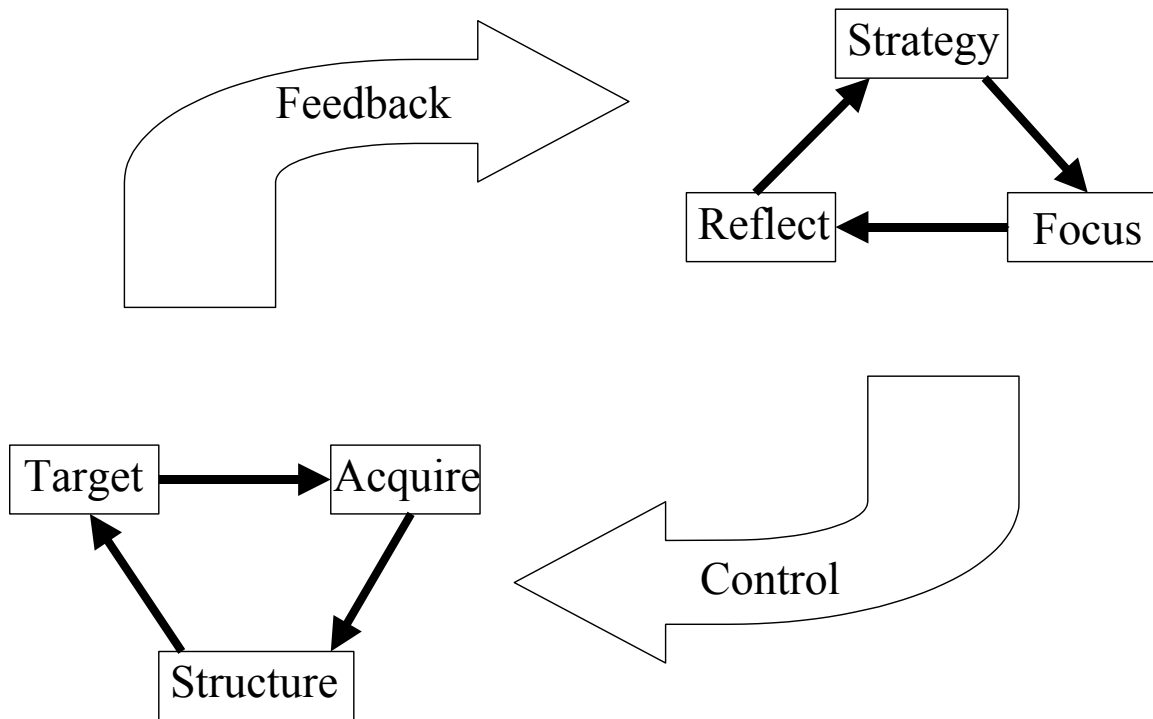


Figure 5. The Dynamic Alignment of Knowledge Engine [after Ref. 8]

3. Nissen's Extended Knowledge-Flow Dynamic Model

Nissen extends the Nonaka model by adding the time and knowledge cycle dimensions. The Nissen dynamic model focuses on the flow dynamics to inform the design of information systems and business processes to enhance the flow of knowledge through the enterprise. The model leverages the quantitative understanding of flows in engineering and information systems to extend the knowledge flow theory that can lead to "devices" of considerable utility in the enterprise knowledge domain. The resulting model is a four-dimensional, dynamic model that can be used to classify and visualize a diversity of knowledge-flow patterns through the enterprise. These patterns can, in turn, be analyzed to inform the design of useful information systems and business processes. [Ref. 14]

The Nissen model addresses the knowledge flow with more dimensions, by integrating time, reach, and explicitness dimensions with Nonaka's model.

4. The Department of the Navy Knowledge Management Model

Knowledge management involves the balancing of technology, information, processes and individual and organizational learning within a culture of shared values. The DON has developed a model to serve as the framework for knowledge management projects underway, providing attributes that accrue to successful projects. Components of this model are:

- Technology - Enabling, facilitating, promoting innovations
- Content - Value, relevancy, currency
- Process - Making explicit, capturing, categorizing, clumping, synchronizing, analyzing, disseminating
- Culture - Commitment, sharing, exchanging, building relationships
- Learning - Building context, creating, growing, thinking strategically

As Knowledge Management initiatives are propagated across the Navy Department, this model serves as a template to assure that information management systems address the elements that facilitate the creation of knowledge. [Ref. 37]

The helm shown in figure 6 conveys the notion of the model guiding a ship (organization) to its destination.

One of the ways that DON CIO distributes the explicit knowledge on KM design and implementation is by means of a CDROM, called Cport, which is freely distributed (by request at the DON CIO website). DON CIO has distributed over 17,000 CDROMs to help KM efforts across the fleet. The CDROM is updated annually; the year 2002 version is planned for release in August.



Figure 6. The Department of the Navy Knowledge Management Framework [from Ref. 37]

5. DSMC Military Fellow Knowledge Management Framework

Defense Systems Management College (DSMC) military fellows Cho, Jerrell, and Landay propose a knowledge management framework with three components (the authors call them pillars): People, Processes, and Technology [Ref. 6]. It conveys the importance of each of the three pillars, that is, if any one of the pillars is removed, the KM program collapses. The KM strategic plan, KM processes, KM projects/applications, and KM performance measures are unified under this framework. Figure 7 shows this integration.

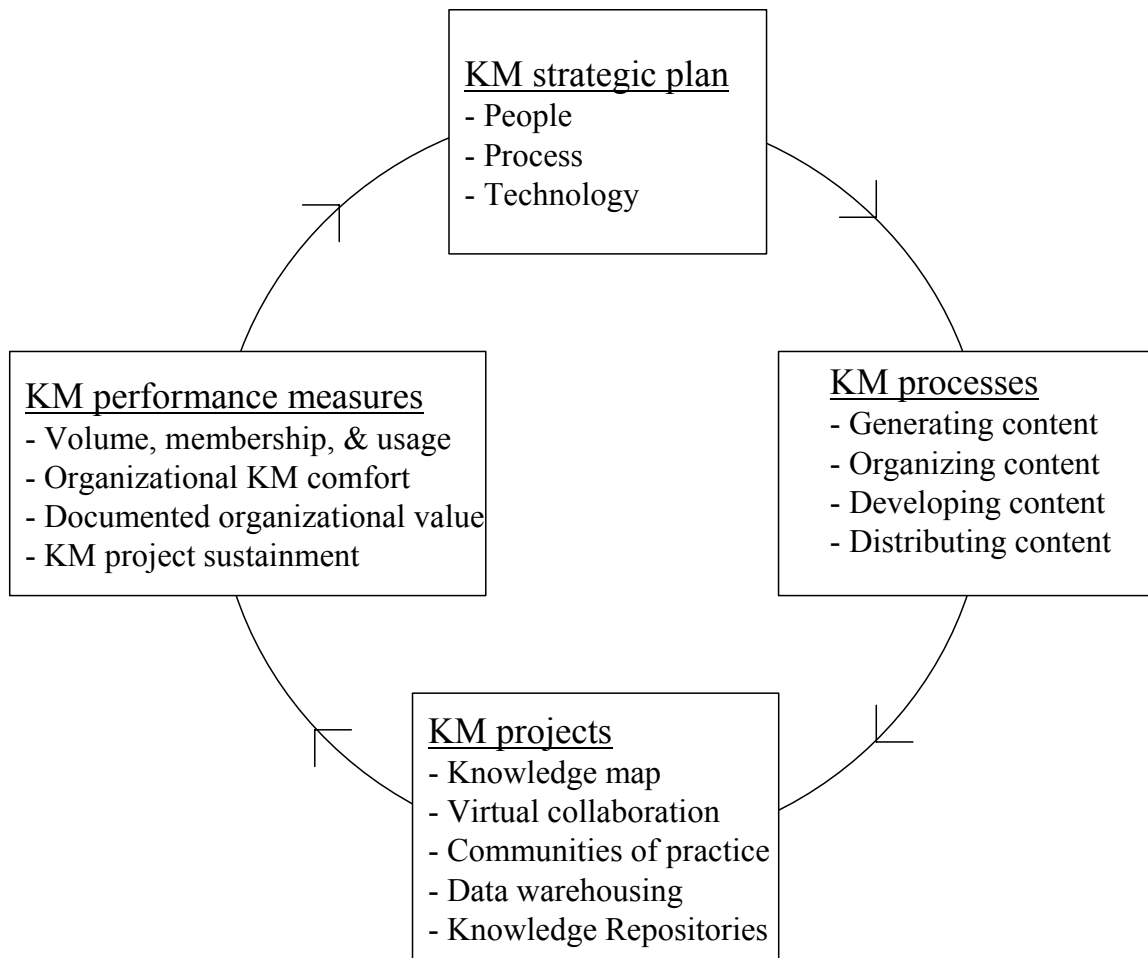


Figure 7. Knowledge Management Framework [after Ref. 6]

E. INFORMATION TECHNOLOGY

There is ample coverage of KM in the Information Technology (IT) press [Ref. 9, 28, 46, 53, 54]. A detailed survey of IT/KM tools in the market place would fill hundreds of pages. But, it should be emphasized that Information Technology is not Knowledge Management. Many researchers have concluded that leading KM with IT is sure to fail [Ref. 34, 44, 45, 47]. Three of the four quadrants in the Nonaka knowledge spiral are centered on people. IT only shines in the combination quadrant [Ref. 45]. However, most KM conferences (and the accompanied trade shows) now resemble IT bazaars. The advances in IT have convinced many that effective KM is just getting the right set of IT tools to “warehouse” the knowledge. Most knowledge management conferences tend to be trade shows for software vendors. The message is: "Buy my software and you will have knowledge management now."

However, IT is an essential element to enable KM. Anyone who has used text-based search engines knows that they are inadequate since they return too many irrelevant hits. A search that returns half a million hits does not help the seeker of knowledge. User sensitive capture, context sensitive retrieval, and taxonomy based smart agents are becoming the latest technologies being developed to gather customized information for the user. [Ref. 46] Government agencies in the intelligence analysis communities have been the first adopters of such technologies due to the glut of raw data and information collected but not analyzed and correlated. [Ref. 37, 46]

There are three major classes of IT tools to search for relevant information: human assisted classification, text-based search engine, and taxonomy software. Human knowledge classification is time consuming and is subject to the bias of the classifier. A text search engine "crawls" through every document on every computer hard drive in the company to create an index for quick retrieval of relevant information. But keyword search also produces too many returns to be useful, especially in time critical situations. Taxonomy software provides a middle ground between all-human knowledge classification and pure keyword search. These software applications automate the categorization of unstructured data bits and information pieces across the entire organization. Autonomy uses algorithms similar to those used in fingerprint matching and other biometric identification; they are discovery and exploration tools. Autonomy does not understand the content of the document; it does look for certain words in the document, their frequencies, the proximity to certain words, and similarity measure of one document to another. It then suggests to the knowledge seeker a list of relevant documents. [Ref. 31] Some examples of taxonomy software products are:

- Autonomy (www.autonomy.com)
- IBM/Lotus (www.lotus.com)
- Stratify (www.stratify.com)
- Verity (www.verity.com)
- Quiver (www.quiver.com)

Companies have tried for years to capture corporate memories before they disappear (departure of key personnel, time, down sizing). Artificial Intelligence (AI) in the 1980s was trumpeted as a way to capture the knowledge of experts by digitally

encoded it into an AI framework. Not much really happened and most of the research efforts were shut down. In fact, it became difficult to secure funding if one mentioned AI in the proposal. AI and expert systems fizzled out. [Ref. 30, 31]

AskMe (www.askme.com) is a KM solution that works like a traditional document repository but it is built on a foundation of experts. The user types in a question and AskMe crawls through servers and generates a page of documents and the profiles of experts relevant to the question. The user can then review the document list and contact the experts directly via email, phone, instant messaging.... etc. [Ref. 31]

Tacit Knowledge Systems' Knowledge Mail (www.tacit.com) uses nouns and phrases that appear in email messages and attachments to create a catalog of experts. It is often difficult in a business to find people to answer questions when most workgroups are located in diverse locations and may not know the existence of subject matter experts in the some organization. By with Knowledge Mail, one is pointed toward someone who is an expert based on the organization's email artifacts. This approach is similar to reading journal articles and combing through the references to identify the experts. Knowledge Mail has the potential to be a time saver when trying to locate the experts. The obvious drawback is that employees may not want their emails scanned and probed for relevant content. [Ref. 31, 46]

F. ORGANIZATIONAL CONSIDERATIONS

Knowledge creation requires people-to-people interactions. People sustain the KM process and make the knowledge management system work. Thomas, Kellogg, and Erickson emphasize the importance of the organizational aspect of KM:

Knowledge management is often seen as a problem of capturing, organizing, and retrieving information, evoking notions of data mining, text clustering, databases, and documents. We believe that this view is too simple. Knowledge is inextricably bound up with human cognition, and the management of knowledge occurs within an intricately structured social context. We argue that it is essential for those designing knowledge management systems to consider the human and social factors at play in the production and use of knowledge. [Ref. 47]

Eric Raymond's paper "The Cathedral and the Bazaar" explains the open source software movement. The theme of the paper is that open source development produces more reliable software faster than the software process driven by closed source development. Contributors to open source software development are self-selected and they choose to participate because they are interested in the project. The infrastructure of the INTERNET relies on many open source products. The most well known examples are Apache, Mozilla, sendmail, Domain Name Server (DNS), and LINUX. The INTERNET would not be as robust as it is without these products. LINUX's popularity as a "bullet proofed" INTERNET server Operating System illustrates the market acceptance of a reliable product. LINUX is the first project to make a conscious and successful effort to use the entire world as its talent pool, made possible by affordable computers and accessible high data rate connections (i.e., The INTERNET) [Ref. 55].

Why do people want to give away their intellectual capital (in this case software source codes)? The reasons usually cited are ego-boosting, reputation among peers, mutual exchange of insights with peers, and altruism. It may be argued that these are the same reasons for people to support a successful knowledge sharing culture [Ref. 6].

The real expense in KM is not the management; it is keeping the knowledge fresh and useful [Ref. 31]. How do you make it possible for people across the company to find knowledge when they need them? [Ref. 46] Top management must make KM a priority and support the project with sufficient resources and staff the project with interested users. The loyalty of the knowledge worker is to his/her knowledge community and not the organization per se [Ref. 40].

Sharing is inherently a human interaction. A knowledge management system adds no value if workers are unwilling to share their knowledge. The organization must reward those who participate in the sharing culture. Many researchers have concluded that KM must start from the people angle or a bust is all but guaranteed [Ref. 6, 34, 40, 41, 56-58].

G. CHAPTER SUMMARY

When it comes to leveraging knowledge, the public sector is no different from the private sector. The same rules apply to both. The only difference is that private organizations have profit as the bottom line, while public organizations have mission accomplishment instead. Knowledge management has applications in both commercial and military arenas. In the commercial sector, the objective of knowledge management is to leverage the collective wisdom of an organization's people to improve performance. In the DoD acquisition management arena, knowledge management takes on an important role since the requirements have increased while the knowledge base is shrinking. Knowledge management is seen as a way to improve acquisition management performance by leveraging the entire workforce's knowledge. In the military operations arena, the rapid operational tempo of the joint U.S. military demands accurate information for command decisions to win battles.

A systematic approach to design knowledge management systems is essential. Models provide frameworks to understand the knowledge flow to optimize information systems and business processes so that we may maximize the return on investment. However, only people can capture the contextual richness of a diverse set of data, information, past experience, and observations in order to synthesize new knowledge. Knowledge management can only be considered as successful if it enables people to make better and faster decisions.

The editorial in the May 6, 2002 issue of Federal Computer Week cites a study conducted by the Gartner Group saying that the government was the "worst group by far" at Knowledge Management. The government scored only 2% compared to the 78% by top organizations. The main problem, the editorial asserts, is that government employees do not understand that knowledge management is a discipline supported by technology, rather than a technology itself [Ref. 27]. The study does not address some of the interoperability successes in the uniformed military though.

Knowledge Management is here to stay, it may be called something else in the future but its premise is so fundamental that it must be incorporated as the norm for successful organizations.

III. RESEARCH METHODOLOGY

A. INTRODUCTION

The objective of this research is to design a knowledge management initiative at a major shore activity of the Naval Sea Systems Command (NAVSEA). The organization targeted for this pilot project is the Submarine Electromagnetic Department (NUWC DIVNPT Code 34) at NAVSEA's Naval Undersea Warfare Center in Newport, Rhode Island.

There are three main areas of the research methodology to support this knowledge management initiative. The first area involves a literature review of current trends in knowledge management and a thorough examination of the KM models and frameworks employed in other DoD acquisition management commands. Other sources of research information include INTERNET searches and review of knowledge management practices at other organizations. Having an understanding of the history and recent advances in knowledge management are essential to formulate a KMS design that fits the attributes of the targeted organization.

The second major area of research methodology consists of review and analysis of two recent surveys, the first one is a study on the implementation and effectiveness of Integrated Product Teams (IPT) in two Systems Commands and the second survey is a command wide survey conducted at the Naval Undersea Warfare Center Newport Division (which is one echelon above the targeted organization in the command hierarchy). Results obtained from analyzing the IPT survey are used to guide the design of team oriented knowledge management applications (or projects) such as communities of practice, cross-functional teams, and inter-departmental collaborations. It is expected that the targeted organization's cultural environment could be inferred from the analysis of the command wide survey.

The third area of research methodology is the gathering of feedback from the targeted organization's users on current knowledge management processes, culture, and information technologies. Qualitative research methods used include surveys, interviews, and direct observations to evaluate the targeted organization's current state of data,

information, and knowledge sharing activities and analysis of the gap between the current and desired states.

As discussed earlier, this knowledge management initiative is divided into three phases: discovery, prototyping, and design. The data, information, knowledge, and insights required to execute these phases are supported by the research methodology.

B. DESCRIPTION OF RESEARCH METHODS

Several research methods are employed to address the three major areas of the aforementioned research methodology. They include literature review relevant to the thesis topic, qualitative methods such as surveys, interviews, participant observations, and content analysis of survey narratives. For the IPT survey, a statistical method called Contingency Table (or Two-way table) is used to determine the dependence of sample attributes.

1. Researching Knowledge Management Framework and Models

The first step for this thesis research is to conduct an in-depth literature review of current knowledge management theories, strategies, models, and on-going knowledge management efforts in government and industry. The Department of the Navy's knowledge management model consists of five components: Technology, Content, Process, Culture, and Learning [Ref. 37]. Defense Systems Management College (DSMC) fellows Cho, Jerrell, and Landay propose a knowledge management model with just three components (the authors call them pillars): People, Processes, and Technology [Ref. 6]. The Cho model is more concise since Content, Culture, and Learning in the Navy model are really people related components that may be combined into the People component in the Cho model. This three-component model also conveys the importance of each of the three pillars - that is, if any one of the pillars is removed, the KM program collapses. Nissen's knowledge flow model is included in this research because it provides an integrated framework to describe knowledge cycle of creation, organization, formalization, distribution, application, and evolution [Ref. 14]. Nonaka's model of tacit-to-explicit knowledge transformation is included because it links the three pillars of

people, processes, and technology to the knowledge transformation processes of socialization, internalization, combination, and externalization [Ref. 18]. The goal of this research methodology is to define knowledge management strategies (e.g., changing reward system), processes (e.g., knowledge flow), projects or applications (e.g., community of practice), and performance measures (e.g., usage of knowledge portal) for the targeted organization.

2. Reviewing Other Organization's KM Systems

Knowledge Management programs in organizations having similar functional areas are also reviewed with respect to the knowledge management and knowledge flow models identified in the literature review. Two separate entities are selected for this review; they are MITRE Corporation and Portsmouth Naval Shipyard. MITRE's major functional area is government sponsored Research and Development whereas Portsmouth Naval Shipyard's core function is the operations and maintenance of submarine repair activities. The targeted organization's scope of work consists of Research, Development, Test and Evaluation (RDT&E) and Operations and Maintenance (O&M) functions. It is expected that the best practices and lessons learned from other organizations could be adapted for use in the design of a knowledge management system.

3. Performing Content Analysis

The targeted organization participated in a command level survey in 2001 in which about 1500 out of 2700 NUWCDIVNPT employees completed the survey. More than 100 of the 190 employees in the targeted organization completed the survey. In addition to the numerical answers, over 900 narrative comments were submitted as part of the survey. For this thesis, narrative responses relevant to the design of a knowledge management system are analyzed to obtain insights into the employees' attitude regarding collaborations and knowledge sharing. Content analysis is the research method chosen to analyze the 200 pages of single-spaced verbatim narrative responses.

Content analysis is a research method used to determine the presence of certain concepts within texts. Researchers quantify and analyze the presence, meanings, and

relationships of words and concepts to make inferences about the message of the texts. An analysis begins with the definition of research questions and the selection of texts. By reducing the text to categories consisting of a word, set of words, and phrases, the researcher can focus on patterns that are indicative of the research question. [Ref. 59]

For this thesis, content analysis could answer some of the secondary research questions regarding KM enablers and obstacles in the organization. The words and phrases chosen for content analysis are: teaming, team, integration, collaboration, stovepipes, cooperation, cross-department, communication(s), culture, and process. Text coding is performed by tabulating occurrences of the selected words and phrases. Once the text is coded, the researcher analyzes the frequency data to draw conclusions that address the research questions.

4. Using Contingency Tables

A qualitative study on integrated product teams (IPTs) in Navy Systems Commands conducted by a group of PD-21 students in late 2000 is also reviewed to understand the effectiveness of team collaboration [Ref. 60]. The demographics of the forty-nine persons in the sample reflect that of the targeted organization. Since team effort is usually associated with knowledge sharing, it is instructive to examine the results of this study for insights on forming a high performance knowledge management organization.

This quantitative method is used to re-analyze survey data collected from the IPT study. For example, one may want to find out whether a person's assessment of a management initiative depends on his position in the hierarchy. The contingency table method refers to the statistical analysis of bivariate count data to determine whether two variables are independent. It uses the Chi-square test of independence to decide between the null (the two variables are independent) and alternative hypotheses. [Ref. 61]

The mathematical description of the contingency table method may be found in Appendix A.

5. Conducting Surveys at the Targeted Organization

A small sample size survey is conducted at the targeted organization to assess the state of knowledge sharing efforts and employee attitude on collaboration. The questionnaire contains fourteen questions, all requiring narrative answers. The categories of the questions are mentoring, information technology, communications, knowledge distribution in the organization, and personal awareness of knowledge sharing efforts. The questionnaire (see Appendix B) is sent via the command's electronic mail to a random sample of 25 employees in the targeted organization. Three categories of employees received the survey; they are project engineers, program managers, and new hires (under two years at the organization). Those who do not respond within one week receive telephone follow up or face-to-face visit. However, it is made clear from the outset that participation is purely voluntary.

6. Doing Interviews

Follow-up interviews are designed to collect more details about the interviewee's answers to the survey questions. The goal of the interview is to dig deeper into the answers provided in the survey and to try to determine what works and what does not work in the department's knowledge sharing activities. Similar to the survey, the interviewees are selected from project engineers, program managers, and new hires. The interviews are conducted so as to minimize the imposition of predetermined responses when gathering data. Questions posed permit respondents to answer in their own words. The questions are designed to elicit information about the respondent's experience, feelings, thoughts and/or opinions. Probing questions are used to deepen the response to a question, to increase the richness of the data being obtained, and to give cues to the respondent about the level of response that is desired. Common questions used as probing devices might include:

- “When did that happen?”
- “What was your involvement in the situation?”
- “How did that come about?”

To encourage elaboration, the interviewer might use these kinds of statements:

- “Would you elaborate on that?”
- “Could you say some more about that?”
- “That’s helpful. I’d appreciate if you’d give me more details about that.”

Before the interview begins, the interviewee is informed of the purpose of the questions and how the data would be used. The ground rules of anonymity are reiterated. Responses remain confidential and all data is aggregated. Names are not used and quotes are not attributed to projects or organizations. An interview always begins with questions that are non-threatening and easy for the interviewee to answer, e.g., “How long have you worked here?” Such questions are necessary because they serve as icebreakers. The interviewee is given sufficient time and the opportunity at the end of the interview to ask any questions regarding the study. [Ref. 62]

7. Observing Participants

Observational Research is the process of watching people in context, in their natural environment, doing routine activities. It is a method used to ascertain what people really do instead of what they say they do. For example, very few people would openly say that they withhold information from colleagues. The goal of observational research is to capture the embodied knowledge, that is, tacit, nonscientific knowledge - the type of findings that cannot be uncovered in surveys and focus groups. To that end, the researcher can pay attention to minute details that can often be overlooked. [Ref. 63]

Leonard and Rayport call this observation method empathetic design. Empathetic design can access five types of information which traditional surveys and interviews cannot. They are:

- Triggers of use: what makes people use your products or service? Are they using it in the way that you expected?
- Interactions with the user's environment: how does the product fit into the user's unique operating system?
- User customization: does the user reinvent or redesign the product to better suit his/her own purpose?
- Intangible attributes of the product: e.g., are certain webpage layouts more attractive to the knowledge workers?

- Unarticulated user needs: the observation of consumers encountering a problem that they do not realize can be fixed or may not even view as a problem. [Ref. 64]

For this research, the observations take place in meetings, program reviews, personal interactions, and various forms of electronic communications.

C. MAPPING THE RESEARCH METHODS TO KMS DESIGN PHASES

Three developmental phases are planned for this thesis. They are the discovery phase, prototyping phase, and design phase. The research methods are selected to support this phased KMS development; the usage of particular methods for the phases is shown in Table 1. Table entries are coded to denote usage level of each method in a particular phase: '3' denotes significant usage, '2' denotes some usage, '1' denotes little usage, and '0' denotes no usage.

Table 1. Mapping Research Methods to KMS Developmental Phases

<i>Method</i>	Discovery	Prototyping	Design
<i>Researching Knowledge Management Framework and Models</i>	3	3	2
<i>Reviewing Other Organization's KM Systems</i>	2	2	2
<i>Content Analysis</i>	2	1	0
<i>Contingency Tables</i>	2	0	0
<i>Survey of the Targeted Organization</i>	3	0	0
<i>Interviews</i>	2	1	0
<i>Participant Observations</i>	2	1	0

D. CHAPTER SUMMARY

The objective of this research is to design a knowledge management initiative at a major shore activity of the Naval Sea Systems Command. The entity targeted for this pilot project is the Submarine Electromagnetic Department (NUWC DIVNPT Code 34) at the Naval Undersea Warfare Center, Newport, RI.

Three main areas comprise the research methodology to support this knowledge management initiative. The first area involves a literature review of current trends in knowledge management and a thorough examination of the KM models and frameworks employed in other DoD acquisition management commands. Other sources of research information include INTERNET searches and review of knowledge management practices at other organizations. The second major area of research methodology consists of review and analysis of two recent surveys. The third and final area of research methodology is the gathering of feedback from the targeted organization's users on current processes, culture, and information technologies.

Research methods used for the development of this thesis are discussed. They are literature research, evaluation of other KM programs, content analysis of survey narratives, statistical analysis of data, surveys, interviews, and participant observations.

IV. RESEARCH RESULTS

A. INTRODUCTION

This thesis research is an in-depth evaluation of a DoD organization and the subsequent process redesign to improve knowledge-management (KM) capabilities at a Naval Sea Systems Command (NAVSEA) field activity. The targeted organization for the initiative is the Submarine Electromagnetic Department of NAVSEA Newport, Undersea Warfare Center Division. The initial goal is to enable the targeted organization to gain a competitive advantage in its areas of excellence with the long-term goal of expanding the KM initiative across the entire NAVSEA enterprise in order to maximize NAVSEA's operating efficiency.

This chapter focuses on the results of the discovery, prototyping, and design phases to initiate a Knowledge Management System (KMS). It provides an analysis of the knowledge flow process at the targeted organization and the obstacles that must be overcome to allow a KM culture to take root. A knowledge management system design is proposed using the results from the discovery and prototyping phases.

As in the design of any complex system, the first step in a successful knowledge system design is to define the concise system requirements that would satisfy the intended users' needs. The discovery phase explores the organization's knowledge practices and the tools currently in use to facilitate the knowledge flow. In addition, the targeted organization's culture, people, processes, and information technology are evaluated to determine where gaps may exist. The discovery phase is the most extensive of the three phases and much of this chapter is devoted to the reporting of discovery phase results.

Prototyping is the second phase of the development. It consists of the activities used to try out knowledge management tools, develop collaboration methods, and define knowledge management processes to make knowledge sharing the normal organizational behavior.

The final step of the KMS development discussed in this chapter is the design phase. Lessons learned and best practices distilled from the discovery and prototyping

phases are synthesized in this phase to design a knowledge management system that is appropriate for the targeted organization with the explicit goal of making it more competitive and nimble by leveraging its core competency. Strategy is formulated and the processes of the organization are redesigned to enhance performance through knowledge management. Knowledge management tools, methods, and processes are integrated in this phase to support KM system deployment. A set of relevant performance metrics is defined to evaluate the resultant KM system against the organization's needs.

B. RESULTS FROM THE KMS DISCOVERY PHASE

An action research method is employed to gain an understanding of the culture, people, processes and products of the targeted organization in order to design a KM system that fits the entity. The discovery is directed toward the exploration of the organization's knowledge practices and the tools currently in use to capture/create, organize, formalize, distribute, and apply knowledge. In addition, the targeted organization's culture, people, processes, and information technology are analyzed to determine where gaps may exist. The data collection for this thesis consists of surveys, selected interviews, and direct observations of the organization's personnel. Analysis results are used to understand the dynamics of knowledge transformations in the targeted organization. Knowledge management programs at other organizations with similar work functions are reviewed to identify behaviors and characteristics that work for them. The results from two recent surveys are analyzed to obtain insights into the organizational climate, team dynamics and work attitude in order to customize the proposed knowledge management system design for the targeted organization.

1. Literature Review Results

This thesis research begins with a literature review of current knowledge management theories, strategies, models, technologies, and on-going knowledge management efforts in government and industry. This section reports the literature review results. The three main subsections are knowledge management models, the U. S.

Navy's knowledge management effort, and information technologies to enable knowledge management.

a. Knowledge Management Models

The overarching framework used for this KMS development is the Cho, Jerrell, and Landay model. It is a unifying framework that encompasses all facets of knowledge management design, implementation, and sustainability. The KM framework is a continuous cycle, as described in Chapter II, that starts with the formulation of knowledge management strategies, moves on to the development of processes, design of projects or applications, and finishes with the definition of performance measures. The cycle then repeats to address new knowledge management requirements. [Ref. 6]

Nissen's knowledge flow model is included in this research because it provides a logical decomposition of knowledge flow functions (creation, organization, formalization, distribution, application, and evolution of knowledge) that facilitates optimal mapping to information technology [Ref. 14]. This model fits within the knowledge management processes in the Cho KM framework.

Nonaka's model provides a useful way to categorize various KM projects (e.g., knowledge map, community of practice, data warehouse ... etc.) with respect to the knowledge transformation mechanisms: socialization, internalization, combination, and externalization [Ref. 18]. Nonaka's knowledge transformation model is used to evaluate candidate KM projects in order to achieve a balanced portfolio of KM projects, in terms of people, process, and technology, to sustain the knowledge community.

These three models (discussed in more details in Chapter 2) provide the framework for the targeted organization's KMS development.

b. The Navy's Knowledge Management Effort

In June 1999 the Secretary of the Navy, the Chief of Naval Operations (CNO) and the Commandant of Marine Corp (CMC) jointly released the Department of the Navy (DON) Information Management & Information Technology Strategic Plan for

FY 2000-2001 [Ref. 65]. The Navy's chief information officer (DON-CIO) developed and distributed a CDROM-based guidebook (called Cport, first release in August 2001, new version planned for summer of 2002) to champion, develop, and participate in communities of practice. This is a detailed guide to aid Navy commands to start, manage, and support communities of practice. However, few people in the targeted organization know about the office's knowledge management effort. An electronic request for the current version of the Cport CDROM was not acknowledged (an expected customer service action in all successful e-commerce).

Closer to the targeted organization, the goal of integrating geographically dispersed and culturally different operating units (the targeted organization being one) into a unified corporation is one of the 'critically few' initiatives of the Naval Sea Systems Command (NAVSEA). The former commander of NAVSEA, Vice Admiral Pete Nanos (who retired in June 2002), introduced the branding concept in 1999 to unify the NAVSEA organization. NAVSEA is responsible for shipbuilding, fleet maintenance and repair, new weapon systems acquisition, weapons stations, research and development (R&D) centers and contract administration. NAVSEA is a large organization with revenue that would rank it as one of the top U.S. corporations. However, there are many different programs, field activities (SUPSHIP and shipyards), detachments, and research centers with different ideas of what the corporate strategic goals are. The fragmentation and the functional overlaps create inefficiency, in-fighting, mediocre responsiveness to the fleet customers, and in general, a lack of cohesion. According to VADM Nanos, the fleet has always complained that getting service from NAVSEA is frustrating. [Ref. 52]

Another NAVSEA 'critically few' initiatives is the maintenance Enterprise Resource Planning (ERP) program [Ref. 5]. Procedures have been re-engineered to yield a set of common processes. Commercial Off the Shelf (COTS) software packages are used to link together the shipyards, depots, regional repair centers, nuclear regional maintenance depots, and every single navy ship. The result is a single, up-to-date, and global database so that the entire corporation uses common resource planning information.

VADM Nanos' vision is to realign the resources of the entire corporation to serve the needs of the customers (the fleet). He instituted training within the corporation to pitch the market oriented concept, changed the identification badges of all NAVSEA entities to the same design and introduced a uniform company logo for all correspondences. Teaming across entities inside and outside the corporation is encouraged when such teaming provides value to the fleet customers. [Ref. 5, 52]

An indication that DON recognizes the need to share information and knowledge is the universal insistency that acquisition programs should not re-invent the wheel. The NAVSEA program managers are now routinely asking about the level of collaboration and external reviews in the execution of their technical programs. The typical questions are:

- "What related work (in the entire DoD, industry, and academia domains) have you surveyed in formulating your technical approach?"
- "How do you keep up with the current advances in you field?"
- "Has this been done before in the XYZ project?"
- "What is the difference between this approach and so-and-so's approach?"
- "What are the internal and external peer review processes for this proposal?"
- "What can we leverage from the following programs?"

While this line of inquiry may annoy some people, it provides an incentive for technical personnel to do their homework. The research process involved to avoid duplicated efforts is no different from the process of preparing a refereed article for a professional journal. A note of interest is that information on industrial research is usually easier to obtain than similar work in other DoD entities. This is counter-intuitive but not surprising given the zero-sum nature of government research funding (your gain is my loss). Industries are eager to advertise their research efforts; many use their research work as loss leaders to get future development and production contracts.

While the team concept is frequently touted as the centerpiece, its successful implementation depends on the same elements. They are clear objective, power to act, no hidden agendas, mutual trust, technical expertise, and common vision. As VADM Nanos pointed out, the fragmentation, in-fighting, and overlapping functions

are obstacles to the creation of a knowledge sharing culture. Unless the fundamental issues are addressed, knowledge management will continue to be a vision and not a reality in NAVSEA.

There is no disagreement regarding the need and utility of knowledge management in the Navy, but most of the actions appear to be top-down proclamations without an integrated approach to convince the entire organization to embrace the changes. New process initiation actions such as awareness training, storytelling, rewards, new hire indoctrination, and formal education are not implemented uniformly across the enterprise that would allow the Navy organization to leverage all its knowledge resources. In short, the strategic goals have not been communicated to the deck-plate level to encourage changes to occur. A bottom up approach to attack the obstacles at the working levels with support (vision and resources) from the top down is essential to implement knowledge management.

c. Information Technology for Knowledge Management

Knowledge management facilitates the creation and sharing of knowledge and information technology (IT) is an important enabler. IT tools should be non-intrusive and easy to use (require little or no additional training). What are the essential IT capabilities for a knowledge management system? The literature review indicates several must-have capabilities. They are the ability to contribute to the corporate knowledge repository and/or data warehouse, ability to find data/information/knowledge, ability to find topical experts within the organization, ability to communicate with others with similar interest, ability to organize work groups to collaborate, and ability to access the corporate knowledge from anywhere, at anytime [Ref. 6]. While many software vendors promise knowledge management nirvana with their products, it is essential to remember what the planned knowledge management system must do for an organization. Concentrating too early in the solution space (how) without understanding the problem space (what) is one of main reasons that programs fail [Ref. 66].

Email is the basic technology for electronic communication for all Navy organizations. Its need is so self-evident that nobody really questions the return on

investment of this IT tool. But the number of emails coming into each person's mailbox has increased many folds. The sheer volume of mail has become unmanageable; let alone integrating the information content to synthesize new knowledge. Most people set up folders to manage their email messages but the folder view is inherently a hierarchical file system that makes it difficult to retrieve information. We have all experienced the exasperation of trying to find a piece of email or file that is buried deep in the computer file folder structure. Misfiling or lack of cross-referencing of items that should belong in multiple project folders further complicates the search. What technology can we leverage to structure the influx of information so that we can make sense of it, use it, retrieve it, establish connections among the pieces, and create new knowledge? The concept of relational database is appropriate to relate pieces of information so that ad hoc query is possible to view the data/information from multiple views. A relational map is drawn based on the content to allow visualization of the relationships among the pieces of data and information that exist in multiple email folders. Several software products, out of many in the market place, promise this relational connection, they include Six Degrees by CREO (www.getsixdegrees.com), Knowledge Mail (www.tacit.com), and AskMe (www.askme.com).

Another common tool in the IT toolbox is the search engine. A search engine does not have the capability to read people's mind but it can construct a user profile based on previous searches and html access log entries. This is a useful feature given that many users do not use the logical and proximity operators available in most search engines (e.g., Google, Yahoo, and Alta Vista) to construct a targeted query.

Automatic customized delivery of information and knowledge that suits the user's need is the hottest application for knowledge management. In particular, these computer software products continually analyze the user's IT usage behavior (email content, bulletin board postings, file access, favorite webpages ... etc.) to define a customized profile so that information may be pushed based on the user's interest. These taxonomy software products are gaining popularity in DoD (especially in the intelligence community) and the private sector. Some examples of this type of IT products are Autonomy (www.autonomy.com), Stratify (www.stratify.com), and Verity (www.verity.com); they all appear to have the right set of features to achieve this

customization to some degree. Communities of practice may be inferred from the users' aggregate information technology usage. This method of dynamically identifying the interest groups is probably far more efficient and relevant than using static resumes from the personnel office.

Electronic mail and search engines are common IT tools that are available to all in NAVSEA. The exploding volume of emails, however, robs the users' precious time to try to manage. The email/file cataloging and taxonomy software products cited could provide relief but are quite expensive (\$300+ per seat). In the current budgetary environment, they are unlikely to be widely deployed across the NAVSEA enterprise.

2. Survey and Interview Results at the Targeted Organization

A survey of employee opinions was conducted at the targeted organization to assess its existing knowledge sharing attributes (Appendix B contains the list of questions used in the survey). Eighteen of the twenty-five surveys were completed and returned within two weeks of the distribution date. The first handful of responses was returned within two days and they contained more descriptive narratives than the later returns. Nine follow-up interviews were conducted to elicit more in-depth information on specific questions, with each interview lasting less than thirty minutes. The key findings from the surveys and interviews are discussed in the following subsections.

a. Informal Technical Exchange Seminars

Informal, short seminars lasting no more than thirty minutes during the workday are viewed as good ways to share project information among interested parties, according to all the respondents. Everybody is aware of the department's monthly brown bag seminars and most of the people surveyed attended at least one in the past three months. Several respondents (who migrated from other NUWCDIVNPT departments) would like to see presenters from other organizations so that potential opportunities to collaborate may be discovered. Attendance at the monthly brown bag seminars is good for the new hires. The veteran workers are less likely to show up unless the topic is in their particular work area. Top management attendance is also low; this fact is noted in

some of the surveys. There is considerable desire expressed by the respondents to participate in lectures given by the senior technical staff on the core competency areas of the department.

b. Utilization of Information Technology Tools

Electronic mail is by far the most common IT tool used to communicate and get information. Email access is available locally at each person's desktop and remotely from off-site locations as long as one can connect to the world wide web (WWW). Most of the respondents favor merging knowledge management IT tools into the current email system such that it becomes an integrated entry point into the planned knowledge applications. On the flip side, the mass distribution of all-hands emails tends to be ignored. Some employees set up filters to automatically delete emails from several well-known corporate originators of irrelevant mailings. Unfortunately, the department's INTRANET and technical discussion bulletin boards are not well known to the respondents, accounting for their low usage. Most people use search engines to find information on the INTERNET. Google and Alta Vista are the most common ones mentioned. The NUWC INTRANET is used often to find phone numbers, check travel approval status, get command news update, and query procurement information. The technical library site is less well known than expected, one person complains about its slow response.

c. Mentoring and Succession Planning

There is consensus from the new hires that most senior members appear to be too busy to mentor or share knowledge. Several new hires and veteran workers note the lack of a formal indoctrination program to get the basic set of knowledge to be productive as soon as possible in the organization. A frequently asked questions (FAQ) link on the departments INTRANET is suggested.

d. Knowledge Sharing Culture

Individual experience varies regarding the organizational climate to share information and knowledge. Most people are web-centric enough to find general information electronically but access to specific program or project level information is uneven. Experienced mentors would definitely help to scale the learning curve as well as transfer tacit knowledge. The younger groups are more willing to share than the older ones. The veteran employees seem to resist sharing. Surprisingly, most programs in the department do not have repositories of documents. These program documents reside in the computers of people directly involved and usually are not easily accessible. Finding out about common interests across programs is not easy if one does not already have established personal connections. Many respondents express the need for an employee skills database to identify ad hoc teams to support proposals, special projects, and tiger teams. This feature is similar to a knowledge map that associates an organization's expertise to people. Currently, the targeted organization does this by word of mouth. The apparently weak sharing culture could well be caused by the increased demand on individuals' time by the paying sponsors.

3. Observations Research Results at the Targeted Organization

Observations research was conducted over the past year to generate another view of the targeted organization and its environs. The targeted organization's scope of work (electromagnetic systems) is outside the main stream of sonar, combat direction, and torpedo systems work performed by the other departments at NUWC DIVNPT. In the days before the need to integrate submarine warfare systems for better combat performance (driven by network centric warfare), the departments were free to operate as separate 'companies'. Each department had its own set of sponsors and contacts; the turf was divided and there was little incentive to cooperate across the departments. These turf battles and the isolationist mentalities of the departments have been noted by the sponsors and in the employee opinion surveys as detrimental to the overall reputation of the command.

a. Observed NUWCDIVNPT Management Initiatives

At the NUWCDIVNPT center level, several initiatives are implemented to encourage inter-departmental collaborations: the Science and Technology Community Center, Total Systems Engineering Initiative, and the NUWC University. The Science and Technology (S&T) Community Center maintains a website on the center's INTRANET to distribute information on S&T funding opportunities, event calendar, and pointers on preparing proposals. It also contains a list of the center's technical leaders and senior fellows representing the center's core competency. The existence of this website, however, is not well known even to the people involved in Science and Technology work. The Total Systems Engineering (TSE) initiative focuses on providing innovative system-level (not point) solutions to address the requirements of the Future Naval Capabilities, FORCEnet, and Transformational Technologies. The TSE team comprises of engineers, scientists, and managers from all departments to guide the center-wide proposal effort. NUWC University provides on-site university level instruction to all interested employees. Technical experts within NUWCDIVNPT are recruited to lecture; employees may be funded directly to attend classes or they may attend on their own time. No overhead (indirect) funding is currently allocated to cover the time for the lecturers or the students. Despite the funding shortcoming, these are opportunities for employees in different departments to meet and discover mutual interests. NUWC University's offerings of lifelong learning opportunities are illustrated in Figure 8.

The fleet support function has received much attention due to the emphasis on serving the Navy end-users. Naval Undersea Warfare Center Division Newport (NUWCDIVNPT) has taken steps to implement processes to support VADM Nanos' market-oriented concept. One of the more notable efforts is the integrated shipboard equipment installation program office. The departments in NUWCDIVNPT have been performing installations (and removals) of equipment on board submarines and surface ships independently for many years. Each project uses its own team, internal process, and fleet liaison channels to put electronics equipment on board ships for special ops and/or testing. Many times, the NUWCDIVNPT teams would have conflicting schedule and technical requirements on the same ship, in the same compartment. An installation by one project may degrade the functionality of another project's system. The

potential loss in corporate credibility is obvious. A coordinated team approach is essential to excel in NUWCDIVNPT's fleet support functions. Quarterly meetings are held to review the entire organization's performance.



Figure 8. NUWC University Offerings

b. Observed Collaboration and Knowledge Sharing Activities

In support of the NUWCDIVNPT's initiative to revitalize its Science and Technology (S&T) portfolio, the targeted organization created the Technology Council. Its mission is to identify S&T funding opportunities and assist engineers and scientists to develop winning proposals. The membership of the Technology Council consists of senior members interested in mentoring and guiding the human resources of the organization to perform innovative research. The technology council is also the official sponsor of the monthly brown-bag technical seminar. These seminars allow people to learn about projects outside their immediate areas of interest. The informality of the forum encourages free discussion. People to people connections are developed that serve

as building blocks for a community of practice. Most of the regular attendees are new hires and they seem to be enthusiastic about the chance to learn about other people's work. The author routinely uses technical presentations to find people to work on his projects. Unfortunately, it is unusual to see many senior staff members at these seminars.

Another goal of the technology council is to increase the department's participation in its core competency areas outside the confines of the Newport base. Attendance at professional conferences has declined over the years due to two factors, the lack of indirect (overhead) funding and the increased individual workload. Refereed journal publications have not been encouraged and receive minimal incentives. There are currently no topical editors for professional journals in the department. The well-endowed programs (using direct funds) can afford to send people to conferences while others have to scramble for travel and labor costs to cover their technical exchange activities. This is a major obstacle to sustainable knowledge creation and it requires proactive management actions to reverse.

c. Observed Usage of Information Technologies

Currently, electronic mail at the organization has been accepted as a primary means of communication and information dissemination. The first thing people do when arriving at the office is turn on their computers and launch the electronic mail (email) program. Electronic mail is by far the most popular point of entry into the organization's information infrastructure. The address book implemented at NUWCDIVNPT covers all NAVSEA commands; anyone in the enterprise may be reached from the desktop. It has been observed that the email page is often the most active page on people's computer desktops during the workday. The targeted organization has a department INTRANET webpage, access to the NUWCDIVNPT and NAVSEA INTRANETS, and electronic mail connection to all the NAVSEA corporate entities. One of the observations on the targeted organization's IT utilization is obtained by surfing its website. The home page contains dated material, indicating a rather infrequent refresh. The technical briefs and presentations page contains useful information but the latest entry is many months old (see Figure 9). The lack of new

content is cited in the survey as a major reason that most in the department do not visit the site regularly. A more telling observation is the program managers' folder. Its purpose is for the program managers to upload their bi-weekly status reports for all to use. The system administrator lamented that he has made the mechanism of uploading as simple as possible (just browse, select file, and hit the upload button) but it does not seem to encourage timely postings from the program managers. One manager has not posted anything in three years. The observation is that a website containing a collection of items does not add value to the knowledge worker after the initial forays if the content is not kept fresh and relevant.

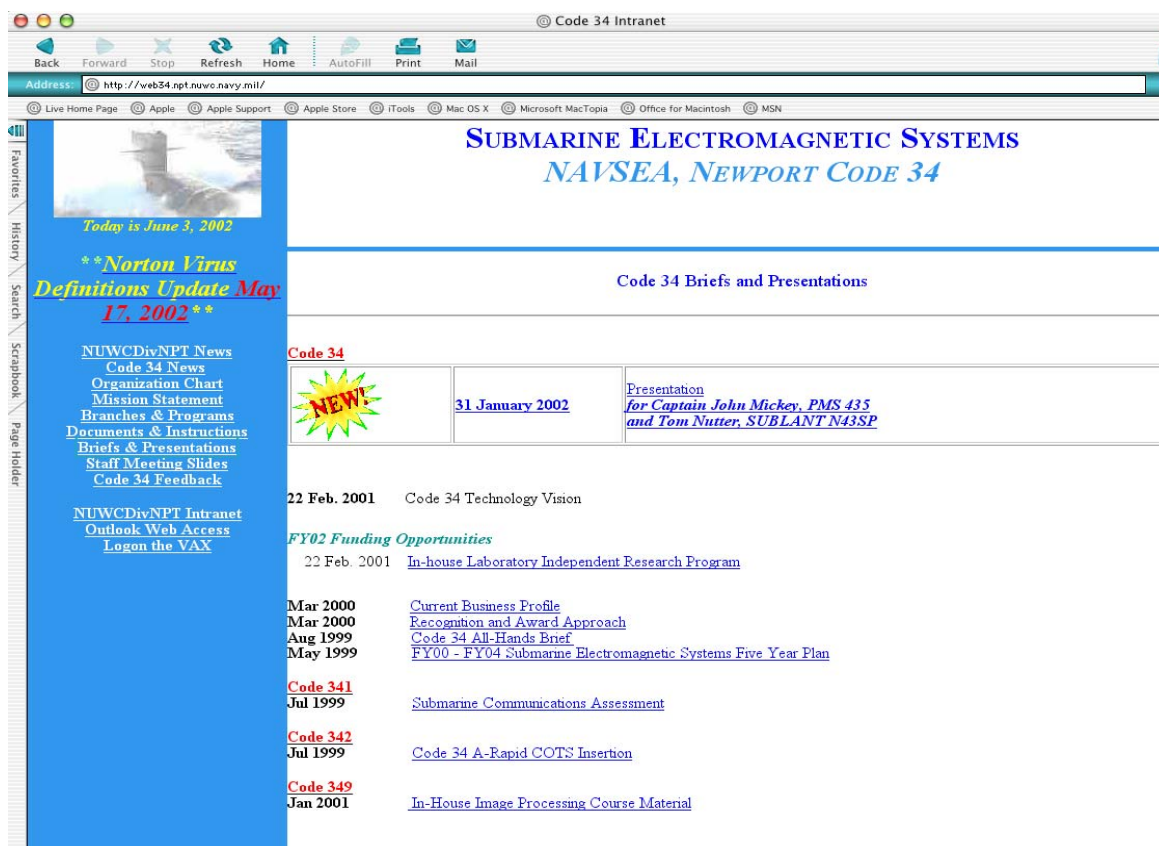


Figure 9. Targeted Organization's Technical Briefs and Presentations Page

NUWC intranet uses Alta Vista as the default search engine; its search domain includes the entire NUWC Newport site. Both 'Simple' and 'Advanced' search queries are available, however, most users do not (or do not know how to) use the advanced search options to refine their searches. The advanced search function includes

logical and proximity operations that enable the information seeker to structure the query to return a more relevant (and smaller) set. A help link associated with the Alta Vista search engine provides a good tutorial but some additional instructions may be required to enable the users to realize the full capabilities of their existing tools. Other search engines are also available on the corporate INTERNET. Defense Technical Information Center's database is accessible through the INTRANET connection to the command's technical library, as are many of the technical publications and professional journals. Many users have observed that the library website has very slow responses because the library does not have a powerful server.

These limited observations on the targeted organization's IT usage reveals that training is necessary for most users to utilize the full capabilities of the available IT tools. The information technologies currently employed at the targeted organization provide a web-enabled environment but far from a knowledge portal (see Chapter II, section C.1). In the information age, the common ailments that plague most organizations are information glut, lack of relevant information, lack of awareness of information elsewhere in the organization, significant duplication of effort, abundance of non-current information, and not knowing where core competency reside. The targeted organization, to various degrees, is afflicted by all the above ailments. [Ref. 42]

4. Other Organizations' Knowledge Management Programs

Two other organizations, MITRE and Portsmouth Naval Shipyard, having similar work functions as the targeted organization, are evaluated to gather information on their best practices, lessons learned, and potential pitfalls. In addition, an example from the operational Navy is presented to illustrate the importance having an optimal (in terms of supply and demand) reward system for knowledge seekers and providers to participate in self-sustaining knowledge sharing activities.

a. MITRE Corporation

On 19 June 2002, two members of the targeted organization met with MITRE personnel in Bedford, MA to learn about their knowledge management design,

implementation, and operations. The attendees were Ms. Jean Tatalias (main presenter), Dr. Varley Wrick from the MITRE Washington DC office, Fred Allard and Anita King from the Bedford office, and Dr. Don Steinbrecher and Dr. Frank Chan from NUWCDIVNPT Code 34.

Ms. Tatalias has a library science background. The MITRE Information Infrastructure (MII) started in 1996 and it spans the entire enterprise worldwide. It is a multi-million dollar operation; the exact annual budget was not revealed. She is the department head for the MII (SES level or flag equivalent). Ms. Tatalis stressed that MII supports knowledge stewardship, not ownership of knowledge across the company. The goal is to encourage horizontal integration. The motto of the project is “No one is smarter than all of us”. Tacit knowledge resides in people; one of the features in MII is to enable people to people connections that facilitate tacit knowledge transfer (i.e., socialization in Nonaka's model). Sometimes the person who has the tacit knowledge does not know it explicitly until the situation at hand pulls it out. People to people connections help tremendously in these serendipitous discoveries. The scope and nature of each project determines the mix of tacit and explicit knowledge. She maintained that MII is not a one-time effort. It has to be maintained and allowed to evolve to meet the needs of the innovative minds in MITRE in order to create solutions for the U.S. government. MII optimizes the knowledge flow within the constraints of resources, security and personal privacy. Initially, there was some resistance with regard to the privacy issue of posting employee information, travel status, and projects.

The entry point into the MITRE information infrastructure is the MITRE portal. It is the standard start up page when one logs in the corporate INTRANET. Every employee is required to enter time card information from this webpage. MII resides behind the MITRE firewall but allows employees to connect remotely via a virtual private network (VPN). The major features on the portal page are time sheet, local weather, upcoming technical events, news, and an enhanced phonebook. The phone book is actually a knowledge map of the organization since it contains the technical expertise, current and past projects of the members. New features are tried and evaluated by a dedicated staff with the goal to enhance user's ability to connect with the rest of the company.

Dr. Wrick emphasized that MITRE is a federally funded research establishment and therefore there is less internal competition than in other entities. MITRE encourages team play and it shapes its hiring criteria based on that core value. Project leaders are expected to be aware of the technical activities in other departments in different locations serving different sponsors. The technical exchange meetings (TEMs) facilitate people to people communications. TEM is an informal MITRE internal forum to share technical knowledge. It takes the form of the technical conference with program chairs, call for papers, and agendas. Since all the departments are involved, the planning workload is spread so that about twenty TEMs are organized each year. The organizational effort takes two to three weeks and each TEM is usually a one-day event. The reach of the meeting is company wide (including the oversea offices) using video conferencing technology. Speakers from different departments present their papers and answer questions. Breakout sessions are hosted to allow more in-depth discussions among active researchers.

MITRE's line managers receive training in leadership and collaboration; the goal is to establish an ingrained culture to foster collaborative innovation. People respond to the culture of their immediate supervisors (not the corporate heads), thus, line managers must change the culture to that of a knowledge sharing one. Reward and incentive systems are in place to provide quick feedback to encourage desired behaviors. Cross-functional collaboration requires effort from all and support from management. MII reduces the communication efforts to collaborate.

MI has a publish-and-subscribe feature, customizable by each individual, to fetch relevant information across the entire network. Employees are encouraged to share their work using personal transfer folders, which are public folders accessible by all. The MI search engine will then be able to catalog/classify files in the transfer folders. KM is part of the workflow, that is, one does not have to open a separate application to get information to support his/her work. The MI staff is testing out an intelligent agent that monitors activities and creates user profiles to further customize the knowledge flow. Dr. Steinbrecher raised the point that overly specific filtering may hinder innovation. He contends that creativity occurs at the boundaries (of disciplines). Information that one normally does not look for specifically may/will provide insights

into difficult problems. One of the desired outcomes of a cross-functional, diverse team is the potential to ‘discover’ an out of the box solution. A homogenous group tends to stay near the center of its expertise and shared experiences. Challenges drive collaborative innovations. The group’s common vision and desire to excel sustain the knowledge sharing community.

As mentioned earlier, people to people connections help tremendously in these serendipitous discoveries. The most used feature in MII is the ‘yellow pages’ that is similar to a knowledge map in function. It contains the following links: staff member’s contact information, the project he/she is working, previous projects, time charged to each project. One can find out quickly the people working on a particular project, the team leader, and the project’s documents. Each person’s link connects to resume, his/her transfer folder, and webpage. This feature allows one to find the right person to talk to, establishing the people to people connection. Not replying to a query is considered a deviation from the norm.

The visit to MITRE provided some very important insights (in terms of people, processes, and people) to aid the design and development of a knowledge management system at the targeted organization. Given the limited resources, however, it is important to choose the applications that yield the greatest return on investment and have the highest chance of success at the targeted organization.

b. Portsmouth Naval Shipyard

Nuclear submarine depot level maintenance is a labor intensive and technically complex operation. The Navy's ship repair industrial base has been reduced by over 50% since the end of the cold war. This assessment of knowledge management activities at a shipyard is based on the researcher's recent personal experience in active and reserve duty service at this particular navy shipyard.

Portsmouth Naval Shipyard has been known in Navy circles to provide high quality work but also has higher cost than its competitors in the private and public sectors. The threat of being selected for consolidation in the next round of base closure and realignment (BRAC) in 2005 has motivated many in this public shipyard to seriously

consider altering its status quo way of doing business. To improve the chance of surviving BRAC, the yard realizes that it is essential to maintain its quality of submarine repair work but reduce the cost and meet schedule. The corporate philosophy to guide this improvement is teamwork, as articulated by the former shipyard commander (Captain V. T. Williams, USN) in his rather blunt all hands memorandum in 1999 (underlined and all CAPITALIZED texts as in the original memo to all hands):

We can be successful through teamwork and only through teamwork. Teams work together cooperatively, using knowledge, experience, common sense, respect, and a focus on a common purpose. One thing that is certain, either the whole Shipyard Team is successful as a business or none of the Shipyard is successful as a business. In team sports the whole team finishes first or none of the team finishes first. It is your opportunity and your choice.

Teams are made up of people. We accomplish our mission with people. To be an effective team there must be trust. To earn trust a team member must have integrity and competence. Integrity is demonstrated by hard work, dedication, and acceptance of personal accountability, commitment to excellence, and a disciplined work approach. Competence is demonstrated by DOING THE JOB RIGHT THE FIRST TIME in your assignment. The business we are in is complex with exacting requirements. No single individual can master it. It takes teamwork to be successful.

We must work through any destructive distrust that exists in varying degrees between management and labor, production and engineering, engineering and quality assurance, the business office and the project staffs, blue collar and white collar, to name only a few. If we are not mature enough to resolve these issues and to develop real teamwork, then our epitaph will most likely read, "THEY SELF-DESTRUCTED." History is strewn with examples of nations, armies, sports teams, and businesses that self-destructed like this. We have the opportunity and choice to take Portsmouth Naval Shipyard to new levels of customer-valued performance or to pass on as has-beens of history. It has been said, "There is no limit to what can be done as long as it doesn't matter who gets the credit.

All teams that win have shared values. The Shipyard's Leadership Council, with deck plate input, has adopted the following shared values. They are communication, respect, decision making, consistency, craftsmanship, work ethic, teamwork, progress, growth and development, and quality cost & schedule performance."

Portsmouth Naval Shipyard is an integral part of the submarine factory program. The program was initiated by NAVSEA to handle the bow wave (or glut) of thirty-five submarine extended depot maintenance periods and refueling overhauls between 2000 and 2007. It was clear to the Navy planners in 1999 that the reduced industrial base of four public shipyards could not perform this ballooning workload unless a fundamentally different way of repairing submarines was devised. The adverse impact on fleet readiness, had the maintenance work proceeded based on the status quo schedule, would have been significant since the number of attack submarines has declined to a marginal level while the national and fleet tasking levels have increased. To prevent this unacceptable outcome, NAVSEA made several improvements to shipyard processes. Until recently, each shipyard did every piece of repair work individually. NAVSEA (in conjunction with stakeholders from the industrial base) determined that dividing up the specialized work among the industrial base might lower costs, improve cycle times, and increase overall efficiency. Lean manufacturing is one of the initiatives under the submarine factory program. Instead of having all the shipyards work on the same piece of equipment infrequently, it is more efficient to concentrate the human and machinery resources to become proficient in specific areas. This process improvement has returned significant cost and schedule benefits to the entire submarine repair industrial base.

Schedule slip translates to cost overrun directly in an industrial environment. Another submarine factory improvement aims to reduce cycle time for nuclear refueling overhauls from about 26 to 28 months down to 20 months, and to bring the depot maintenance periods down from 14 to 16 months to 11 months. The way to accomplish this is through the integration of planning and scheduling tools across all the stakeholders, better long lead time ordering of components and integrated material management, utilization of slack labor resource from other private and/or public shipyards to handle surges in each others yards, and close coordination with vendors to receive parts on time. The mutual sharing of best practices, lessons learned, and innovative processes among the shipyards is essential to the success of the submarine factory program. Its adoption by Portsmouth Naval Shipyard required changes in attitude and acceptance of 'not invented here' best practices recognized by the community.

Civil service employees at the Portsmouth Naval Shipyard understand their professional viability depend on their willingness to do things smarter and to collaborate with vendors, private and public shipyards. They embraced the submarine factory program early on and the shipyard has accumulated a string of success stories since 2000.

In the past two years Portsmouth Naval Shipyard has been able to deliver ships on or ahead of schedule, making it one of the best performing public shipyards in the submarine factory program. For instance, the USS Miami (SSN-755) overhaul was completed 18 days ahead of its already challenging 13-month schedule (and within cost). This is an important accomplishment given that sixteen months was the industry average for similar projects. Captain McCoy, the shipyard commander and Commander Richards, the submarine's commanding officer, both credited teamwork as the essential element for this feat [Ref. 67]. Many submarine factory program improvements were employed throughout this record-breaking project, including integrated scheduling, material management, and sharing of resources with other shipyards. Portsmouth Naval shipyard has set even a loftier goal for its next submarine maintenance project and the yard is sufficiently confident of its ability to deliver that it offers the Type Commander a fixed price contract, a first in the nuclear ship repair business.

An important component of the submarine factory program is knowledge sharing; every shipyard provides end of project briefings to the other shipyards. The idea is to capture the tacit knowledge and make it explicit so that others may use it. Information technology is envisioned as the mechanism to disseminate the community's knowledge. However, use of information technology in the submarine factory program is less prevalent than anticipated. Figure 10 shows the official corporate homepage of the submarine factory program that is titled the Sub Team 1 knowledge sharing forum. The website is an IT tool intended as central repository of lessons learned, best practices, and group interactions artifacts. However, a recent visit to the Sub Team 1 website (July 2002) reveals very little content. Most of the folders are empty. The only folder that is updated regularly is the quarterly meeting minutes folder that is maintained by headquarters program office contractors. Team member contributions to the website are rare and it is not clear how one would upload new files to the repository. The folders'

contents are arranged in a hierarchical structure and no connections are made among the files.

Several explanations for the sparse web-based participation are postulated. They include lack of time, lack of familiarity with the technology, and potential sensitivity of posting nuclear ship repair information in a quasi-public website. People to people connections remain the preferred method of knowledge sharing in this community.

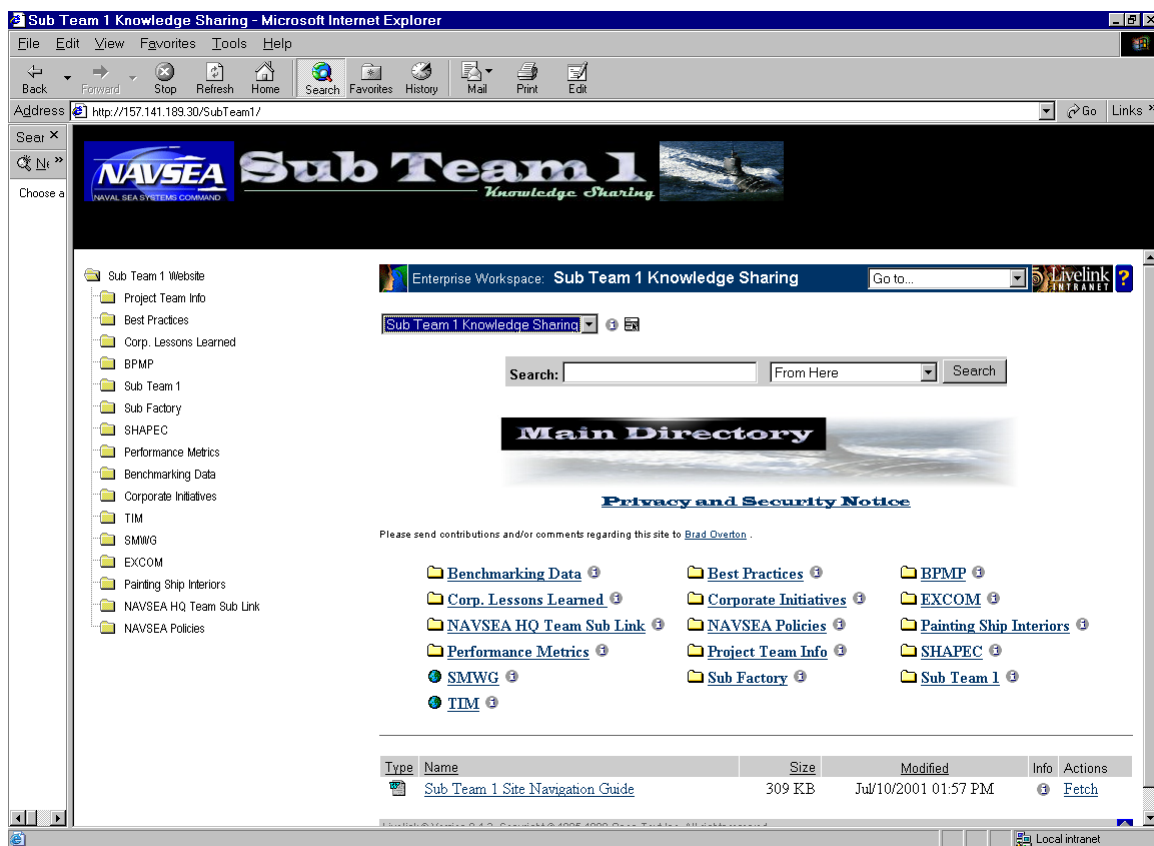


Figure 10. Submarine Factory Program Homepage

The production department at the Portsmouth Naval Shipyard maintains a project team handbook on its INTRANET site to guide the initiation, planning, execution, and closing phases of submarine depot maintenance projects. It is basically a standard operating procedure to run a project. It contains many flow diagrams, process charts, and templates that are useful for a new team to come up to speed quickly. Figure 11 shows

the web homepage for the shipyard's project team. It provides html links to other shipyard enterprise resource management applications and personnel contact information that support the project phases. A project team can gather most of the explicit knowledge it needs in one place for its project. This is a living document, new information is incorporated when the project teams submit lessons learned and/or discover better ways to execute certain tasks. The document is up to revision 17 and all projects use it to formulate their baseline plans.

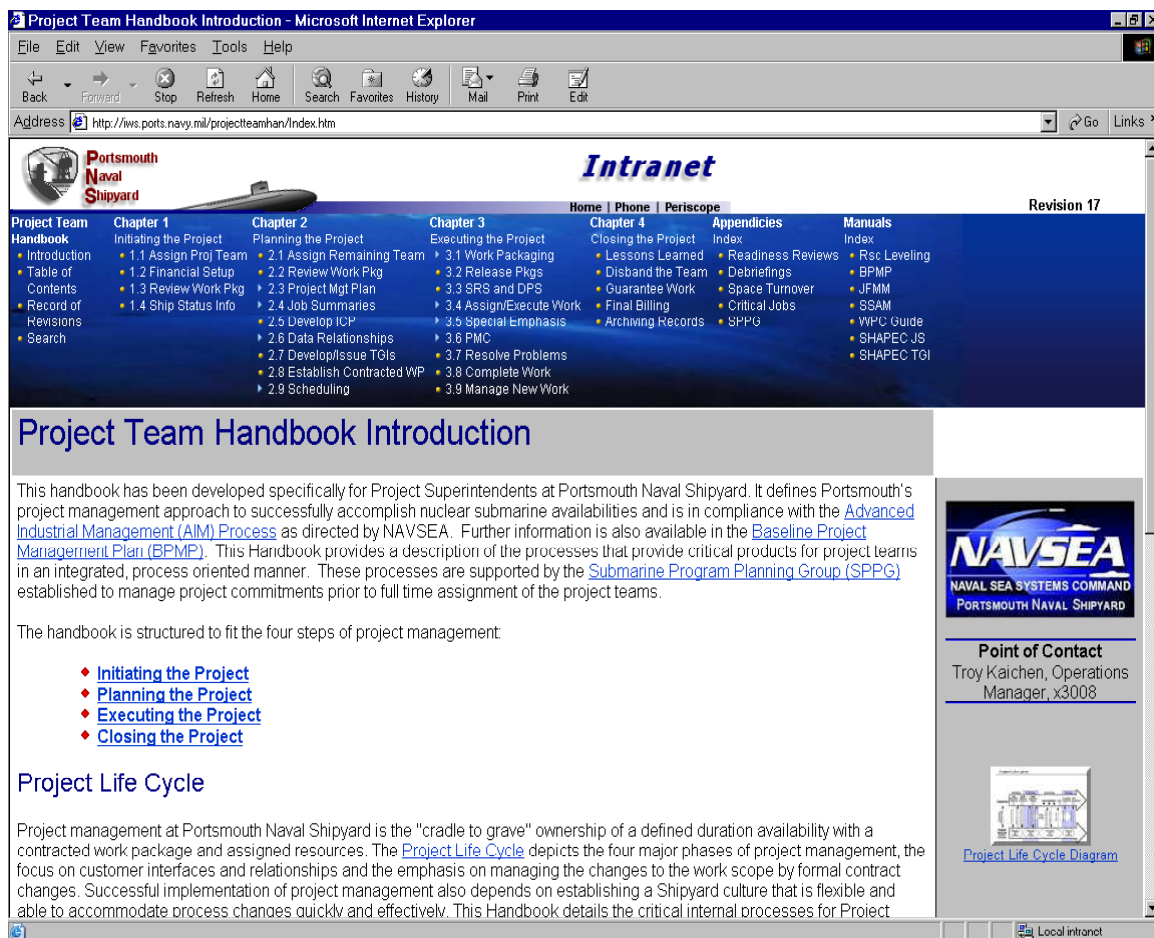


Figure 11. Portsmouth Naval Shipyard Project Management Homepage

Currently, there is no automated mechanism to capture the day-to-day project management artifacts (e.g., job planning documents, daily status reports, issue resolutions, informal correspondences among the project team). This capability may be able to capture some of the more subtle tacit knowledge generated during the entire

project. The 'as it happens' capture of data and information coupled with the participants' timely analysis/synthesis is more valuable than an end of project debrief.

The major takeaways from this subsection on Portsmouth Naval Shipyard are that common goal, shared values, personnel empowerment, standardization of best practice, and tangible rewards are important motivators to change an organization's culture.

c. Knowledge Sharing in an Operational Arena

Nissen asserts that there is some kind of supply and demand (quantity and price) function associated with knowledge sharing. Most organizations set the price (reward) of knowledge contribution too low to stimulate adequate supply. [Ref. 68]

An example from the operational Navy supports the hypothesized supply and demand function of knowledge sharing. Every person, officer or enlisted, assigned to a submarine is expected to qualify as a watchstander. The qualification requires each candidate to master the many facets of submarine operations such as machinery operations, system lineup, capabilities, damage control, ship operations, safety, and security.

A command wide program of formal lectures, self-study, mentoring, on-the-job training, and examinations facilitates the learning process. A candidate who completes all the requirements earns the right to wear the submarine warfare pin, which is an explicit recognition of membership into the submariners' club. The personnel performance evaluation system supports the entire process. The ship's commanding officer is graded on the readiness of his subordinates. The department heads, division officers, chiefs, leading petty officers are all held accountable for the training of their people.

Having more qualified personnel also means that more people share the watchstanding workload, creating a better quality of life (QOL) for all. More qualified people means more time off, an extremely important satisfier (also a powerful predictor of a ship's reenlistment rate) when the ship is in its homeport. Personnel who do not

qualify within the set schedule are required to participate in a remedial program. This means less liberty, more low-level work, and less prestige among peers. The peer pressure is mostly positive, however, the leaders must communicate the common vision and expectations and ensure the peer pressure does not become negative and abusive. The high turnover rate on US combatants requires the qualification program to be a continuous process. A breakdown in any link of the command chain would degrade the ship's readiness rapidly.

Those who are qualified (the knowledge providers) are eager to help train the new people (the knowledge seekers) because of the following reasons: the reputation of the command, the knowledge seekers are shipmates, more watchstanders to share the load, military service is a shared experience, and it is part of the job.

For the system to work, there needs to be significant overlap of the shared interest. The non-qualified personnel are eager to learn because of the following reasons: the reputation of the command, expectation of peers, personal prestige, and it is part of the job.

The supply and demand concept clearly applies here. The suppliers and seekers of knowledge operate in a well-defined marketplace where the metrics (rewards) are clear and understood by all players for the system to operate efficiently. The same knowledge sharing dynamics work in the surface, aviation, and other components of the military establishment.

5. Content Analysis Results of the Employee Opinion Survey

The targeted organization (Naval Undersea Warfare Center Division Newport) conducted employee opinion surveys in 1998, 1999, and 2001 [Ref. 36]. The 2001 employee opinion survey is a 200-question (numerical ranking) survey plus two open-ended narrative questions. Results from these surveys have been briefed to all hands each year by the survey consultants. The broad categories of the employees' feedback have not changed significantly so only the 2001 results are analyzed in detail for this thesis. The numerical responses show some indications of the state of organizational

collaboration but the written narratives contain valuable insights into the culture and practice of the corporate environment of the targeted organization.

Employee feedback relevant to knowledge management system design is examined to infer the organization's readiness for knowledge management implementation. The analysis result is grouped into categories. Table 2 tabulates the positive and negative comments on the organization.

Table 2. Positive and Negative Comments About Own Organization

Preconceived notions about own organization (negative)	Preconceived notions about own organization (positive)
<ul style="list-style-type: none"> • We are told by sponsors in Washington DC that we (the departments and programs at NUWC) don't work well together • Teams will slow the decision-making process and lead to decreased morale • There is a culture of inequality (favoritism) in job assignments in place • Turf wars between codes • NUWC has become technologically and morally bankrupt • Past management was excellent; current management incompetent and detrimental to NUWC's future • Managers are unaware of what employees are doing (evaluations/rewards are meaningless) • Arrogance and covering up mistakes lead to bad decisions • Management does not respect employees or share information with them • NUWC has a bad image in Washington - they (the program offices) called NUWC the "Welfare" (not Warfare) Center - must address this to increase morale and business 	<ul style="list-style-type: none"> • High level of cooperation • Professional work environment • Open to new ideas at all levels • Opportunities to acquire diverse knowledge through migration within a department • Culture of respect and mutual need • We work well in teams • Colleagues are open with knowledge

The survey is analyzed to identify facilitators and obstacles to an effective implementation of KM in the targeted organization. These results are shown in Table 3.

Comments regarding the need for better collaboration, knowledge transfers between older to new employees, and need for changing reward system are the major issues that must be addressed in the knowledge management system design.

Table 3. Facilitators and Obstacles to Implementing KM

Facilitators to implementing KM	Obstacles to implementing KM
<ul style="list-style-type: none"> • Electronic mail used throughout • Productivity rewarded, yet open culture exists • Informality leads to decreased stress and increased productivity • Quality people in place • Environment of productive, effective teamwork in place • Employees are happy working at NUWC • Good communication • Good system of training in place (for new technology) and academics • Management support of training • Opportunities for mentors, education, and job satisfaction are readily available (implies that employees must be willing to take the initiative) 	<ul style="list-style-type: none"> • Not proactive with regard to problems that may and do arise • Need more encouragement from management for cooperation/cross training between departments • Contradiction in goals seen between different department managers • Lack of interest in others' projects • Bad communication • Too much "junk" communication - need more substance • Poor transfer of knowledge from older to new employees • Poor systems of training for new technology • Feeling of distrust between management and employees • Too many stovepipes • Need to recognize and utilize unique skills of individuals • Too much redundancy within and between departments • NUWC structure makes sharing of talents difficult - need to reorganize NUWC • Management does not cooperate with each other - tend to operate independently and exclusively (rice bowl mentality) • Been burned in the past by people taking credit for other's work when they have shared information

While the survey does not contain many knowledge management specific questions, it is clear that there is an underlying need for knowledge management at the

targeted organization as indicated in the employees' comments. Table 4 tabulates some good ideas extracted from the survey that would inform the knowledge management system design.

Table 4. Enablers for Knowledge Management Implementation Ideas from NUWC employees to facilitate implementation of KM
<ul style="list-style-type: none"> • Need to train new employees better • Need more group meetings of department personnel to update all on another people's tasks • Too many new hires leave • Move more employees between departments - cross pollinate • Reward managers who work well with employees • Indirect funding of projects will lead to better cooperation • Rotate managers between departments • Reemphasize ultimate goal of serving the Navy • Refocus on R&D, not money management • Educate (especially new hires) on the Navy's needs and problems so focus can be on solutions • Reward employee innovation and involvement • Spread out workload better • Too many layers of management • Attract more diverse employees and support their time of adjustment with more social services • Publish list of technologies and associated in-house experts • Too much all-hands email • Continue to fund and stress training (continuing education) • Do a better job of marketing NUWC • Establish better teamwork/partnerships with customers to better serve them • Decrease the number of departments/divisions/branches, too much compartmentalization • Evaluations, rewards, and recognitions should be team-based

The results obtained from this analysis of the employee opinion survey seem to agree with the findings obtained from the other research methods used for this thesis. Several key points stand out from the hundreds of narrative pages. The organization must work as a single team with a common vision and shared values (and end the internal

turf wars), it must refocus on its core competency, it must encourage collaboration and sharing, and it must improve the corporate image with its customers (sponsors).

It should be emphasized that only a small portion of the employees provided narratives for the survey; the self-selected nature of this sample may skew the results reported since only the most positive and most negative views may be represented. However, this researcher has observed and experienced many of the same sentiments (good and bad) expressed in the survey. Lack of cross-departmental collaboration, sharing of resources, and marketing coordination are significant organizational problems and could well be the major obstacles to propagate knowledge management culture across the entire NUWCNIVNPT organization.

An unsettling note is that the survey was designed to be anonymous but there were some lingering doubts among the employee population regarding their anonymity. The employees were instructed to mail completed survey packages directly to the survey consultant firm located out of state. To further protect anonymity, the survey consultant firm aggregated the results, typed and grouped the written comments by topics. Even with these steps to safeguard anonymity, the Federated Union of Scientists and Engineers (FUSE) advised employees not to participate in the surveys. Some employees mailed their packages from locations other than their hometowns.

6. Statistical Analysis Results of a Study on IPT

Collaboration, either virtual or in-person, is one of the major components of a knowledge management system. This subsection discusses the characteristics that enable teams to perform effectively. In December 2000, a group of PD-21 students conducted a study on Integrated Product Teams (IPTs) that included surveys and interviews with forty-nine government employees in NAVSEA and NAVAIR from seven different east coast Navy commands [Ref. 60]. The statistical analysis of the data collected from this study yields some very interesting results regarding team culture and attitude in the Navy acquisition commands. Appendix A discusses the details of statistical analysis using contingency tables and it also contains the questionnaire used to collect the survey data.

Several key findings emerge from the analysis of the data. Training is generally not available to prepare people to work in team settings. The analysis results indicate that the leaders in the Systems Commands have not done the necessary preparation prior to deploying IPTs in their organizations. The personal awareness of training guides and training resources is low in both NAVSEA and NAVAIR organizations. NAVAIR's personnel appear to have more IPT exposures. Those in power (position and/or technical) favor IPT since they have the training and time to participate in IPTs. There is also a vested interest for management personnel to support a management initiative. People who work in RDT&E projects do not favor IPT as much as those in logistics. This is understandable since the engineers and scientists are more likely to be introverts and some still consider IPT as another management fad.

In summary, the characteristics of a successful collaborative team are grounded in the basics. They include an articulated goal, strong facilitation, clearly defined roles and responsibilities, power to make things happen, representation from across the solution base (technical competency), good group communications, reasonable team size, commitment by team members and management, and means to reward members.

Not surprisingly the formula for successful change initiatives share common characteristics regardless of an organization's work functions or workforce demographics. The people's needs must be addressed, the common vision must be articulated, and the shared values must become part of the organizational norm for any change initiative to succeed. An Integrated Product Team is usually formed to address specific issues and usually has a short (months) life span. A knowledge management project such as community of practice is more permanent as long as the practice is relevant. It has a less formal structure than an IPT and its membership tends to be self-selected. However, as in IPT, commitment by community members to share openly is the key to maintain the community of practice.

7. KM Requirements for the Targeted Organization

Definition of top-level requirements for the targeted organization's knowledge management initiative is the main output of the discovery phase. Based on the results

reported in the previous sections, the proposed knowledge management system should possess the following characteristics:

- Alignment with organization's strategic plan
- Interoperable with the Department of the Navy's Information Management and Knowledge Management architecture
- Reward system that encourages intra-department and cross-functional knowledge management activities
- Knowledge sharing opportunities in most (if not all) department functions
- Training programs to familiarize personnel with IT tools
- Ability to contribute to the corporate knowledge repository and/or data warehouse
- Processes to sustain the knowledge flow, keep the contents fresh and relevant
- Search capability to find data, information, and knowledge
- Capability to find topical experts within the organization
- Channel to communicate with others with similar interest
- Ability to organize work groups to collaborate
- Method to access the corporate knowledge from anywhere and anytime

C. KNOWLEDGE MANAGEMENT SYSTEM PROTOTYPING PHASE

KMS top-level requirements are inputs for the prototyping phase. Tools, methods, and processes are selected or designed to satisfy these requirements. Prototyping is a risk-mitigating activity used to quickly determine what works and what does not work. The lessons learned from prototyping are more relevant for the eventual design since the end users are involved. During the prototyping phase information technology tools, group building techniques, management initiatives, and other innovative processes are tested for their suitability. The outputs of the prototyping phase are solution components suitable for the targeted organization's knowledge management design.

1. Prototypes for the People Pillar

From the discovery phase results, it is apparent that alignment of the people view to the objectives of knowledge management and the organization's strategic plan is imperative. This subsection discusses the prototyping efforts to change the culture and initiative to incorporate knowledge sharing into the personnel performance review system.

a. Changing the Culture

One of the major findings obtained from the discovery phase is that a sharing culture does not happen by decree from the top. While it is easy for top management to hold an off-site to pronounce that we must pool resources and leverage each other's core competency, it is another thing to achieve that at the working level without a comprehensive end-to-end program to change the culture. A multiple-pronged approach targeting both the current and future employees should be deployed.

The culture change initiative should include certain interlocking elements. It starts with the organization's recruiting, the selection criteria should be biased toward evidence of a prospective employee's team-based and knowledge sharing activities. The goal of recruiting is to replenish the organization with professionals who possess affinities toward sharing.

Secondly, the organization needs to create metaphors and stories from its history to promote the shared values necessary to sustain knowledge management. Military and sports organizations have employed metaphors and storytelling to create shared values. Joseph Campbell, in *The Power of Myth*, asserts that mythology gives us the perspective to relate current events to our shared culture [Ref. 70]. The Department of the Navy also recognizes the value of storytelling and it encourages its use to promote knowledge management.

"Storytelling, the construction of fictional examples to illustrate a point, can be used to effectively transfer knowledge. An organizational story is a detailed narrative of management actions, employee interactions, or other intra-organizational events that are communicated informally within the organization. Conveying information in a story provides a rich context,

remaining in the conscious memory longer and creating more memory traces than information not in context. Therefore, a story is more likely to be acted upon than normal means of communications. Storytelling, whether in a personal or organizational setting, connects people, develops creativity, and increases confidence. The use of stories in organizations can build descriptive capabilities, increase organizational learning, convey complex meaning, and communicate common values and rule sets." [Ref. 71]

Thirdly, the physical arrangements of the workplace should facilitate knowledge sharing. Locating workers who work on similar projects in closer proximity instead of seating them based on the organizational chart would facilitate better information flow. To make this work, the leadership must re-evaluate the appropriateness of the current workspace administration by line managers.

The change that requires the most immediate attention is the final element. For knowledge sharing culture to succeed, the participants must know and trust each other. Compartmentalized groups exist within the organization based on sponsors, work types, and certain demographics. Group building activities such as formal and informal meetings to share information, lessons learned, and 'gee whiz' discoveries should be supported by management, not just with words and funding alone, but through proactive participations. Several efforts have already been initiated to bring people together in a relaxed environment to share information and knowledge. The targeted organization has instituted open 'Brown-Bag' technical seminars that occur monthly during lunchtime. In addition, several project leaders have agreed to experiment with brainstorming sessions to collect ideas for their technical projects. People want to engage in socialization under a non-judgmental environment to create the knowledge sharing culture. Brown Bag seminars and brainstorming sessions are discussed in more detail in the process prototype section (section IV.C.2.b).

b. Incorporating Knowledge Sharing into the Performance Review

As illustrated in the submarine qualification example (section IV.B.4.c), when every level in the hierarchy is held accountable for training an organization's people the free flow of knowledge becomes the norm. Therefore, changing the reward system in

the targeted organization to reward and recognize knowledge sharing activities is the most important people strategy. Incorporating this into the performance plan would require a substantial effort by the management but it also sends a clear message to the targeted organization's personnel that the initiative is important. When a certain behavior is rewarded, it will perpetuate.

2. Prototypes for the Process Pillar

The process pillar supports the organization's codified standard operating procedures. Prototypes in the process area include expanding the scope of the department's technology council, sharing explicit knowledge, and supporting technical exchanges.

a. Expanding the Scope of the Technology Council

The department's technology council was created to help its engineers and scientists pursue funding in science and technology areas. Many of the scientists and engineers are not currently doing research work; in fact 90% of the workload is in program management, contract monitoring, and technical direction agent functions. The technology council also seeks out funding opportunities and identifies the appropriate personnel to submit proposals. In addition to the marketing function, the technology council supports an internal proposal review process to improve the quality and ensure the proposals address the proper perspectives in relation to the sponsors' expectations. An end-to-end approach is taken to ensure the timeliness and quality of the proposals and to help the engineers and scientists through the wickets of the proposal process.

b. Sharing Explicit Knowledge

One of the observations made in the discovery phase is that the program and projects documents are not readily available. Immediate ways to capture the explicit knowledge could be implemented quickly. The bi-weekly staff meeting and program review documents may be captured by requiring managers to submit electronic copies instead of transparencies. The administrative staff would just post these files right after

the meeting. Presentations, white papers, and reports prepared for the sponsors should be handled likewise. Some quality assurance is required to ensure correctness but this would be an expeditious way to capture explicit knowledge.

An abundance of explicit knowledge resides in individuals' hard-drives. This prototype aims to unleash them from the 'C' drives. One mechanism proposed is a call for shared documents event, similar to a call for papers for professional conferences. The targeted organization's technology council and invited editors from other organizations would review the submissions from the workforce. Retired employees may be reinstated as emeritus reviewers; this would also provide an avenue to capture the tacit knowledge that walked out the door during the past years. Documents accepted for posting in the department's shared space would be announced to all hands. Selecting the best document of the month or quarter would further enhance visibility of this prototype. The goal is to encourage document sharing and provide recognition to those who embrace the concept. This activity also improves the quality of the department's products because of the peer review. These vetted documents become an essential part of the organization's intellectual capital, owned and shared by all. A review link should be implemented for users to post reviews on the documents (similar to the Amazon.com reader's book review). Peer ranking of documents may be used as one of the criteria to select the best of the quarter/year. Quantity and quality of the contributions form the foundation to evaluate the prototype's efficacy. To propagate the concept across the NUWCDIVNPT center, the targeted organization should reciprocate by serving on other departments' document review boards. All the documents are made available across the entire command. Sponsors are given access to these documents so that their frequent information requests may be supported more effectively (and consistently) in both cycle time and quality.

c. Supporting Technical Exchanges

Monthly, informal brown bag technical seminars are supported by the targeted organization to exchange technical information across the department's population. These exchanges concentrate on allowing people to congregate to discuss

and share their technical topics of interest. It is envisioned that the technical exchanges would carry into the coffee mess, virtual break room, and possibly collaborative activities. A similar idea is a technical free for all, a very informal casual Friday forum for projects to come in to show their new 'toys' and discoveries. An added benefit is that conference rooms are much easier to secure on Fridays. Minimal level of facilitation would be required if free snacks and beverages are offered.

A more formal technical exchange activity is the department's lecture series. Senior technical staff members should be encouraged to present one or more hour-long lectures covering the department's core competency. The lecture notes and discussion questions would then be posted on the department's INTRANET to stimulate further socializations (tacit-to-tacit knowledge transformation). To realize its intended benefits, the supply and demand function to sustain this activity needs re-examination [Ref. 68].

Another prototyping effort is the use of brainstorming to encourage idea sharing. Brainstorming sessions are designed to encourage out-of-the-box thinking in order to synthesize innovative solutions. One of most innovative design firms, IDEO of Palo Alto, CA, uses brainstorming extensively to generate ideas, lots of ideas. The firm puts into practice Nobel Prize winner Linus Pauling's oft-quoted belief that "The best way to get a good idea is to get a lot of ideas." IDEO's general rules for brainstorming, which are posted in the conference rooms, are to go for quantity, have one conversation at a time, and defer judgment [Ref. 72]. When the discussion veers off course, the facilitator only has to point to the rules to refocus the group. Training for facilitators would be required to run effective brainstorming sessions.

Many companies, such as Pfizer, Merck, MIT Lincoln Laboratory, IBM, and Microsoft, set up their research facilities to enable chance encounters among people. The objective is to allow people to communicate their ideas as part of their social interactions. The use of plant physical layout to increase people interactions is an effective way to foster a sharing/learning environment in the workplace. It also increases staff morale. Several locations in the targeted organization may be reconfigured as gathering places without incurring significant expense.

3. Prototypes for the Technology Pillar

Several information technologies have been incorporated into the department's IT infrastructure. This subsection examines the prototyping efforts in creating knowledge maps, managing technical information repositories, and participating in electronic bulletin boards. As noted by many survey respondents, email needs to be integrated with these prototypes to realize their full potential.

a. Creating Knowledge Map

A useful knowledge management tool is the corporate 'yellow pages'. It is a directory of the experts inside and outside the organization. The starting point for this capability is the employee database and project histories that are available in electronic format from the administrative office. A preliminary skills and expertise database may be generated manually although a software application is more efficient to maintain the currency of the map. Known experts in the organization should be encouraged (enticed) to update the yellow pages of technical expertise. More sophisticated software products that create user profiles automatically are currently beyond the budgetary constraint of the targeted organization.

b. Managing Technical Information

One of the early feedbacks from the technical personnel is that it is difficult to find existing technical information generated by the organization's personnel. This prototype, in conjunction with the sharing of explicit knowledge (section IV.C.1.b), addresses the issue. Some people share their documents in the network neighborhood (shared folders) but unless one is told specifically where to look, the quest is time consuming. To alleviate this problem, a new file server has been procured to host all the shared files and would be made accessible using a search engine. The procedure to upload files should be simple so that the IT-related barrier to share is lowered. Training on the advanced features of the search engines (such as Google's advanced search capabilities and history) would pay great dividend in time saved.

c. Participating in Electronic Bulletin Board

A bulletin board located close to the coffee mess used to be the place where people got information about upcoming events. Employees might elect to post items on the board that might be of interest to others in the group. At the targeted organization, the area allocated to the coffee mess is smaller and the bulletin board has been taken over by workplace safety and environmental awareness posters. An electronic bulletin board (or discussion forum) has been implemented on the INTRANET to enable threaded discussions. Several senior technical personnel volunteer to serve as forum moderators. User feedback and comments are used to evaluate the effectiveness and suitability of the prototyped components to the design phase. The advantage of an electronic board is that topics, contributors, and other attributes may be used to group the postings and it also supports threaded discussions. This is a democratic way to express one's view and this forum does not favor the loudest speaker. The technology council members and senior staff are encouraged to start discussion threads but not to dominate.

4. Preliminary Results from the Prototyping Phase

Many of the prototypes are either in the planning phase or have just started in the past few months so that final results are not yet available. However, the people dimension is just receiving some management attention. The recent group of new employees has been matched with senior staff members who believe in knowledge sharing. Two books on the organizations past, written by an emeritus employee, have been published to chronicle the technical contributions made by the department during World War II and the Cold War. Leadership of the targeted organization should use these stories to instill pride and shared values in the targeted organization. Changing the reward system would require more education across the board on the benefits of knowledge management.

Technology council members have helped the proposal efforts of several engineers and scientists through vigorous peer reviews. The brown bag seminars continue to draw good attendance although the senior staff participation has not increased significantly. The electronic bulletin board appears to be too difficult to use for most

users. The number of bulletin board postings has declined since its introduction; one of the reasons may be that the incentive to participate is not sufficiently tangible. Several lecture series on the department's core competency have been planned for kickoff in FY-2003. Previous lecture series have been well received. It is hoped that the lecture series would raise the participation level in the electronic bulletin board. One of the best practices captured is that scheduling the lectures on specific day of the week, at specific time, and in specific location seems to convey constancy and improve attendance. The brown bag seminar series follows this best practice (see Figure 12).

The screenshot shows a web browser window titled "Code 34 Intranet". The address bar shows "http://web24.npt.navy.mil/". The page has a blue header with the text "SUBMARINE ELECTROMAGNETIC SYSTEMS" and "NAVSEA, NEWPORT CODE 34". Below the header, there is a section titled "Code 34 Presentation Schedule". The text below the title says "The presentations scheduled for the remainder of the calendar year are as follows:". Below this text is a table with three columns: "Date", "Presenter", and "Title". The table contains five rows of presentation information. At the bottom of the page, there is a note: "Note that presentations will be given from 12:00 - 12:30 in the Mezzanine of Bldg 1319." On the left side of the page, there is a sidebar with various links including "Discussion Forums", "Code 34 News", "Organization Chart", "Mission Statement", "Branches & Programs", "Documents & Instructions", "Briefs & Presentations", "Staff Meeting Slides", "Code 34 Feedback", "NUWCDivNPT Intranet", "Outlook Web Access", and "Logon the VAX".

Date	Presenter	Title
9/19/02	David Rivera	Submarine Towed Communications Antennas: Past, Present, Future
10/10/02	Paul Sheldick	360 Degree Panoramic Periscope Imaging Program
10/31/02	Dr. Stephen Davis	Lightning Part 2: Leaders and Return Stroke Fine Structure in New Terminations to Ground in Subsequent Strokes
11/21/02	Paul Mileski	Error Evaluation and Mitigation for the Outdoor Antenna Range
12/12/02	Dr. John P. Casey	ELF Mixed-Path Propagation Model

Figure 12. Up-to-Date Brown Bag Seminar Schedule

A major NUWCDIVNPT leadership upheaval in recent months has put many of the center-wide initiatives on the back burner including the Total Systems Engineering and Science and Technology Community Center.

The idea of creating gathering places at the targeted organization is still alive; renovation of an older building nearby to alleviate the current office space problem may help push this initiative forward. On the technology front, approval for a new file server has been secured to house the targeted organization's documents. However, the prototypes to create and capture explicit knowledge are not fully deployed to collect the

program and project documents. Additional trust building and leadership involvement would be required to unleash the public documents from private domains.

D. KNOWLEDGE MANAGEMENT SYSTEM DESIGN PHASE

Proposing a knowledge management system design for the targeted organization within time and budget constraints is the goal of this phase. EIA Standard IS-632 describes Systems Engineering as "An interdisciplinary approach that encompasses the entire technical effort, and evolves into and verifies an integrated and life cycle balanced set of system people, products, and process solutions that satisfy customer needs [Ref. 59]." Engineering design is more often concerned with the detailed specification of the system components and their relationships with each other. In this case, the end product is a plan to implement knowledge management for the targeted organization.

Results from the discovery and prototyping phases are used to support this design effort. A set of focused performance metrics related to the KMS requirements (section IV.B.7) is defined to measure system effectiveness. The design should also be modular and scalable so that it may be propagated to the larger community. A knowledge management system is primarily a social system, thus, how the system is developed is sometimes more important than what is developed [Ref. 69]. That is, perception is reality in a social system.

1. Knowledge Management Design Considerations

Knowledge management is a process to optimize the effective application of intellectual capital to achieve organizational objectives [Ref. 37]. An iterative design approach is suitable since the needs of the end users are expected to evolve over time, not to mention the unrelenting advances of information technologies. Continuous prototyping should be used to support this evolutionary effort.

Constraints on KMS design include limits on monetary and personnel resources, institutional inertia, and management support. The budgetary constraint at the targeted organization is such that very little indirect funding would be available for the knowledge management initiative. Therefore, it is important to leverage the information

technologies already in place to satisfy the KMS requirements. Labor costs would be partially supported by indirect funding for the IT staff. Several professional staff members recognize the importance of knowledge management and they volunteer their time to facilitate the initiative.

2. Proposed Knowledge Management Design

The overarching model used for this KMS design consists of intersecting people, process, and technology dimensions as shown in figure 13 [Ref. 6]. Individual knowledge management projects (prototypes discussed in the previous phase) in each dimension are assembled into this framework to show the system view of the proposed KMS design. These three dimensions shown in figure 13 are not orthogonal, that is, there are interrelationships among the dimensions that require balance in the overall design. A stimulus applied to the system could generate responses in all three dimensions. The system elements and sub-elements' actual behaviors are affected (usually non-linearly) by the presence of and interactions with each other. An obvious observation is that knowledge-sharing activities are affected by the reward system. Also, there are limits on the ranges of stimuli (and responses); for example, the maximum salary adjustment cannot be boundless and it may only be applied annually.

The people dimension is concerned with executive leadership, organizational hierarchy, communications, employee motivation (reward system), and training. Process dimension is concerned with the activities that lead to functional efficiency, satisfying careers for the work force, and improvement in core competency and performance. Technology dimension is concerned with information management architecture to support the people and process dimensions. [Ref. 6, 37]

The knowledge management system design with respect to the three dimensions is discussed in the following subsections.

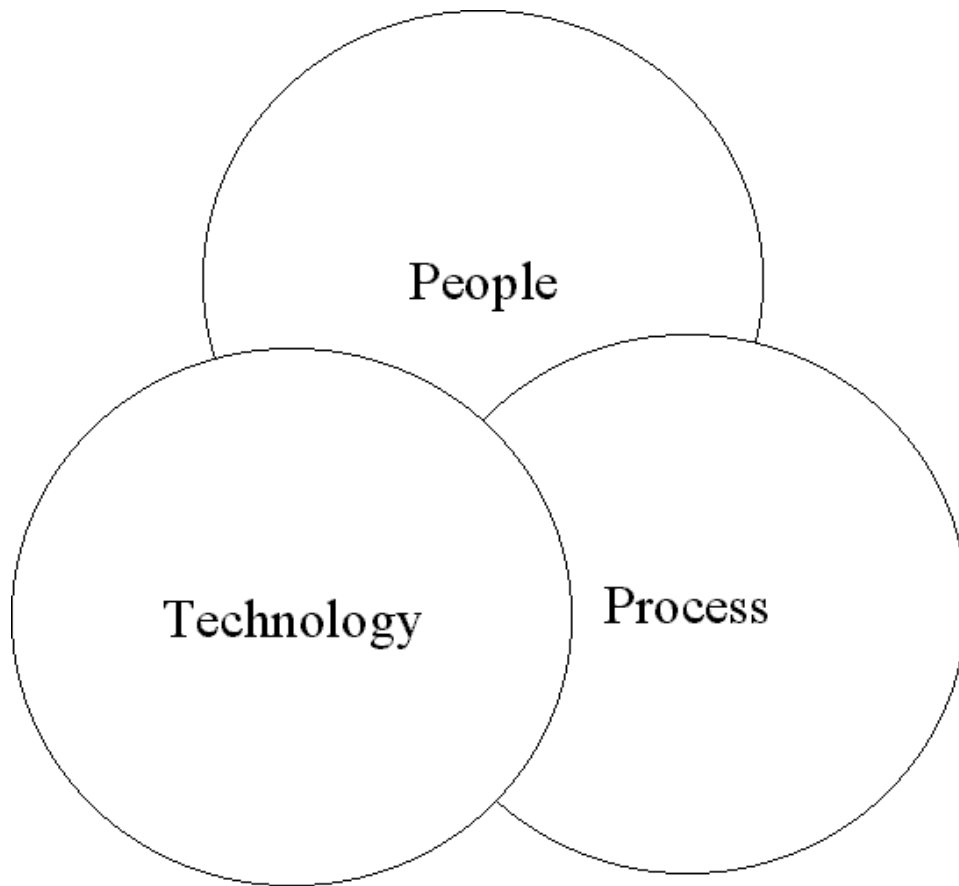


Figure 13. Three Dimensions of the Proposed Knowledge Management System

a. People Dimension Design

The people dimension design in figure 14 is decomposed into two elements in the second level of decomposition and six sub-elements in the third. The people dimension addresses requirements associated with culture change and a reward system for the knowledge management system. People are the essential part of any knowledge management system because they possess the knowledge. The socialization, externalization, and internalization activities described in Nonaka's model of knowledge transformation feature people as the main characters. However, people can also be the biggest obstacle to the success of any initiative. If the environment, culture, and policy do not encourage people to participate then there is no knowledge to share across the targeted organization. The basic assumption for this design is that people are inherently knowledge seekers and they want to perform their assigned tasks well and strive for rewarding careers.

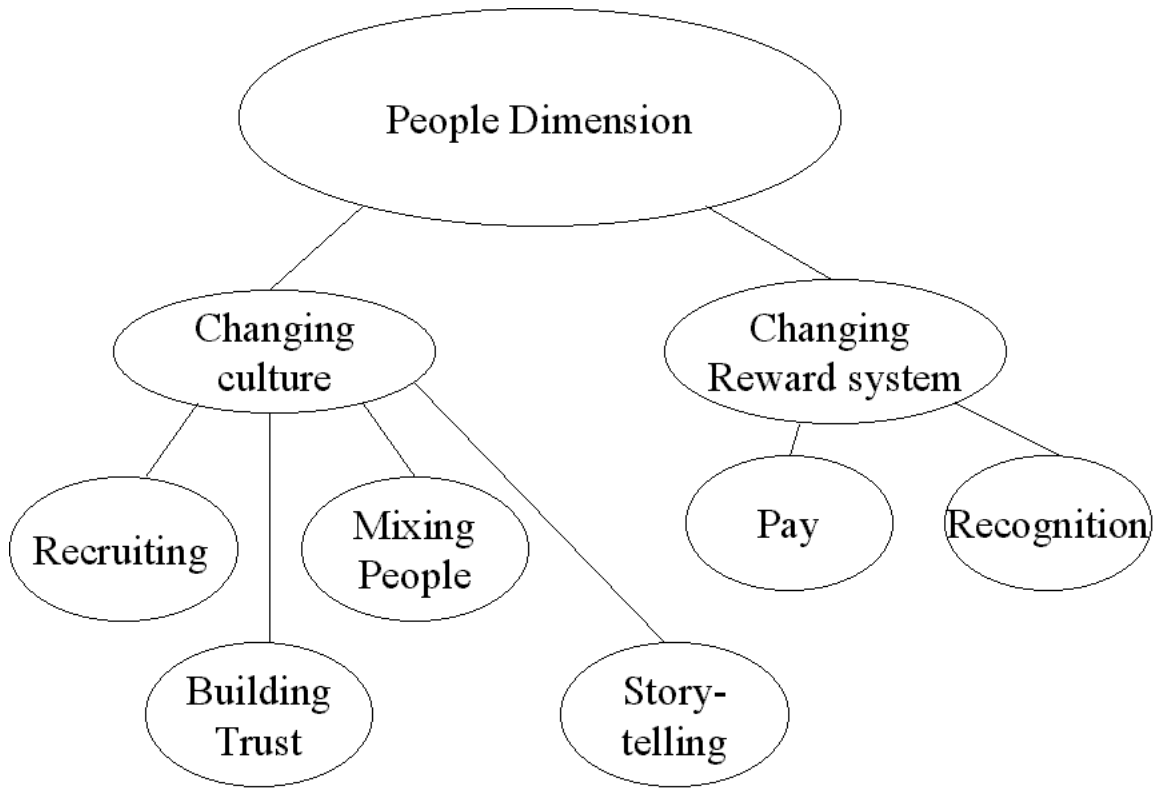


Figure 14. People Dimension of the Knowledge Management System

The three main reasons that people share knowledge with others are reciprocity, reputé, and altruism [Ref. 6]. Table 5 illustrates the relationships of these reasons with people dimension design sub-elements shown in figure 14.

Table 5. People Dimension Design and Knowledge Sharing Reasons

	People Dimension Sub-elements
<i>Reciprocity</i>	Building Trust, Mixing People (local community of practice)
<i>Reputé</i>	Pay, Recognition, Storytelling
<i>Altruism</i>	Recruiting, Storytelling

In order for the KMS design to satisfy the requirements, the function, responsibility, and action required for each sub-element should be clearly defined (see Table 6).

Table 6. Tasking for People Dimension Design Sub-Elements

	Function	Responsibility	Action
<i>Pay</i>	- Monetary reward based on KM metrics	- Immediate Managers	- Incorporate expectations into performance plan
<i>Recognition</i>	- Reward based on KM metrics	- Immediate Managers	- Establish recognition criteria for excellence in KM projects
<i>Storytelling</i>	- Pride in organization	- Top Leadership	- Develop stories with help from emeritus
<i>Mixing People</i>	- Office assignment based on project	- Division Managers	- Revise facility responsibility
<i>Building Trust</i>	- Fairness in reward system. Personal examples	- All Levels of the Leadership	- Have open and frequent communications
<i>Recruiting</i>	- Hire the right people	- Line Managers	- Define criteria for staff selection

b. Process Dimension Design

Process is the second design dimension of the proposed KMS; the relationships of the elements and sub-elements are shown in figure 15. The three elements under the process dimension (technology council, sharing explicit knowledge,

and technology exchange) are designed to enhance functional efficiency, satisfy the work force career goals, and improve core competency and performance. Technology council coordinates the resources of the targeted organization and matches the staff with rewarding knowledge creating tasks.

Sharing explicit knowledge is an asynchronous process to maintain the capture, organization, formalization, distribution, and application of knowledge flow [Ref. 15]. Sponsor participation in this element aims to improve customer relationships and values. Call for documents and selection of the best document of the month (quarter, and year) encourages participation with recognition. Technology exchange creates the environment for tacit-to-tacit knowledge transformation (socialization in the Nonaka's model) and trust building.

Table 7 shows the suggested tasking for the process dimension design sub-elements.

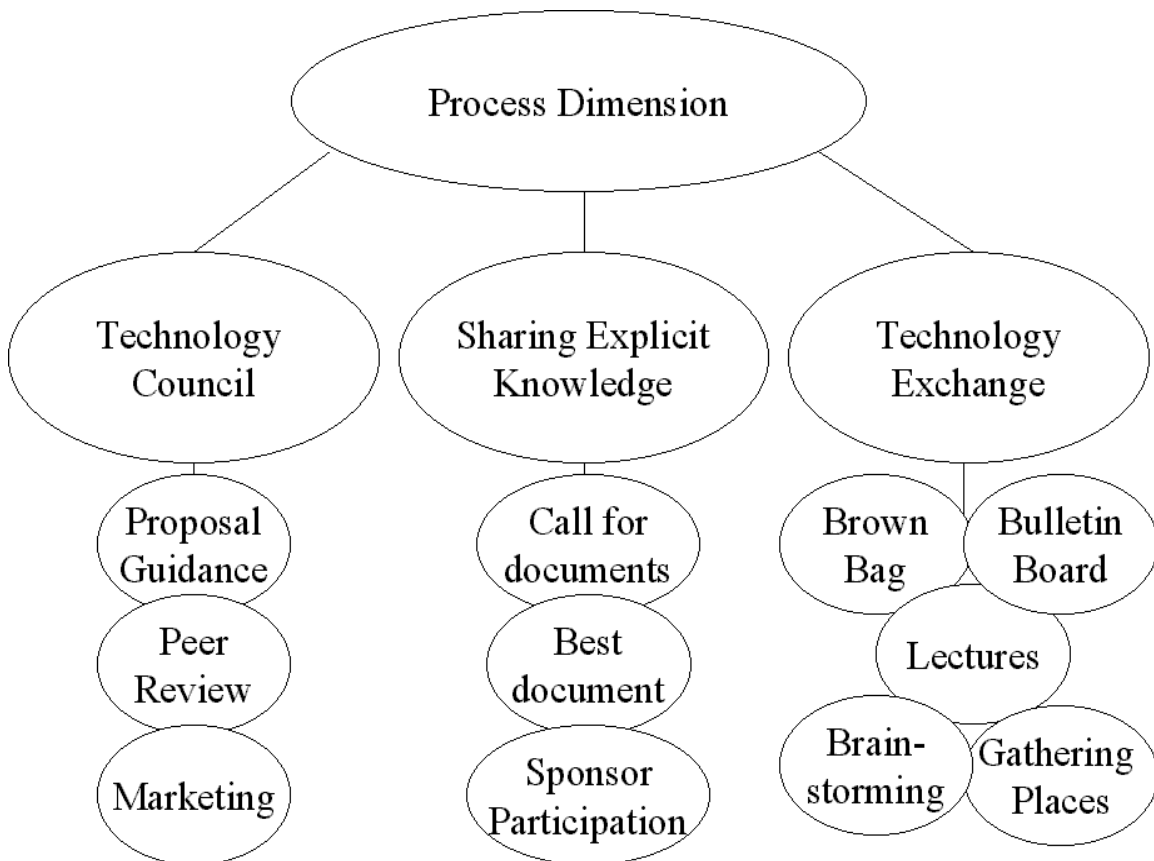


Figure 15. Process Dimension of the Knowledge Management System

Table 7. Tasking for Process Dimension Design Sub-Elements

	Function	Responsibility	Action
<i>Proposal Guidance</i>	- Guide proposal submission process	- Technology Council	- Maintain schedule. - Develop proposal template. - Know own capabilities.
<i>Peer Review</i>	- Ensure proposal quality and relevance	- Technology Council	- Select peer review team. - Understand sponsors' needs.
<i>Marketing</i>	- Increase S&T funding level	- Technology Council	- Participate in external forums. - Know the players. - Seek S&T opportunities
<i>Call for Documents</i>	- Capture explicit knowledge	- Line Managers - Project Leaders - Individuals	- Identify technical areas and Points of Contact. - Design file repository architecture.
<i>Best Documents</i>	- Contributor Recognition	- Top Leadership	- Establish review team and merit based criteria.
<i>Sponsor Participation</i>	- Improve customer relations. Provide added value.	- Program Managers	- Provide financial support. - Demonstrate utility to sponsors.
<i>Brown Bag Seminars</i>	- Forum for sharing technical information.	- Project Leaders	- Prepare technical presentations. - Attend seminars.
<i>Lectures</i>	- Forum to transfer knowledge in core competency areas.	- Core Competency Leaders	- Schedule lecturers. - Encourage attendance. - Make completion a requirement for new hires.
<i>Bulletin Board</i>	- Virtual meeting room to share thoughts, comments on others postings.	- Individuals - Facilitators	- Participate in discussion once a week. - Develop topics of interest.
<i>Brainstorming</i>	- Method to get lots of ideas quickly.	- Project Leaders (with help from facilitators)	- Develop training for project leaders and facilitators.
<i>Gathering Places</i>	- Physical location to meet and interact informally.	- Department Management	- Identify location(s) - Support interactions - Set guidelines for activities and space usage.

c. Technology Dimension Design

Technology dimension design addresses the information management architecture required to support the people and process dimensions. The technology dimension design is shown in figure 16, the elements under this dimension are knowledge map, information/knowledge repository, and electronic bulletin board.

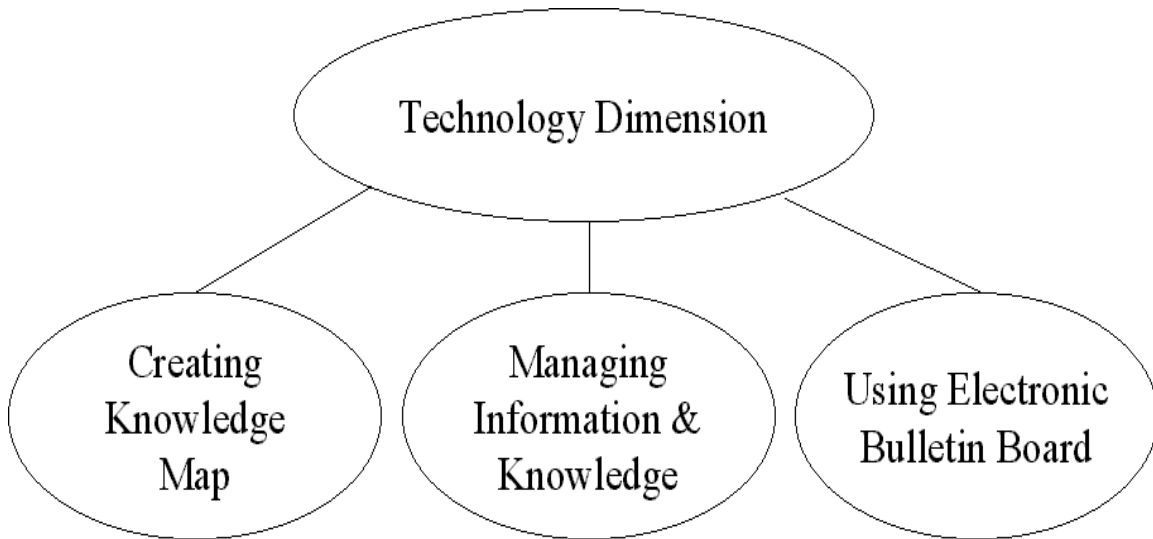


Figure 16. Technology Dimension of the Knowledge Management System

An integrated information infrastructure (similar to the MITRE's MII portal) is essential for the knowledge management initiative. Knowledge map identifies the topical experts; it is the main method to facilitate person to person interactions (socialization and externalization). Effective management of the organizations information and knowledge contents enable all to have access to the intellectual capital. An electronic bulletin board encourages informal discussions that are captured in threads for all to use. It is a sure way to create new knowledge. Electronic mail is the linkage that ties all these elements together into an integrated digital information environment. The primary responsibility to establish IT tools belongs to the department's information technology personnel, however, the conceptual and logical designs is the responsibility of the technology council (with help from volunteer end users). The department managers should provide the necessary funding. Personnel training on the use of these IT tools should be part of the design. Tools that are difficult to operate are useless to the knowledge management participants.

3. Performance Metrics for the Proposed Design

A set of performance metrics, presented in Table 8, maps the KM projects to system, output, and outcome measures [Ref. 73]. Performance metrics are verification measures to ensure that the proposed design meets the knowledge management system requirements (section IV.B.7).

Table 8. Knowledge Management Performance Metrics [after Ref. 37]

<i>KM project</i>	Key System Measures	Key Output Measures	Key Outcome Measures
<i>Portal</i>	<ul style="list-style-type: none"> - Search precision and recall - Dwell time - Latency - Usability survey 	<ul style="list-style-type: none"> - Common awareness within teams - Time spent gathering information - Time spent analyzing information 	<ul style="list-style-type: none"> - Time and money saved - Reduced training cost - Customer satisfaction
<i>Lead Tracking System</i>	<ul style="list-style-type: none"> - Number of contributions - Frequency of update - Number of users - Frequency of use - Navigation path analysis 	<ul style="list-style-type: none"> - Number of successful leads - Number of new customers - Value of new work - Proposal response time - Proposal win rates 	<ul style="list-style-type: none"> - Revenue - Customer demographics - Cost and time to produce proposals - Alignment of programs - with strategic plan
<i>Collaborative System</i>	<ul style="list-style-type: none"> - Latency during use - Number of users - Number of patents - Number of articles - Number of conference presentations 	<ul style="list-style-type: none"> - Number of projects - Number of new products - Value of new sales in past 5 years - Average learning curve - Proposal response times - Proposal win rates 	<ul style="list-style-type: none"> - Reduced cost of product development - Reduced program delay - Faster response to proposals - Reduced learning curve
<i>Yellow Pages (knowledge map)</i>	<ul style="list-style-type: none"> - Frequency of update - Number of users - Frequency of use - Search precision and recall 	<ul style="list-style-type: none"> - Time to find people - Time to solve problem 	<ul style="list-style-type: none"> - Time and money saved - Quality improvement - Efficiency improvement
<i>e-Learning System</i>	<ul style="list-style-type: none"> - Latency - Number of users - Number of courses taken 	<ul style="list-style-type: none"> - Training costs 	<ul style="list-style-type: none"> - Savings - Quality and efficiency improvement - Reduced learning curve

Some tangible measures to evaluate the targeted organization's knowledge management system include the creation of new knowledge (patents, disclosures, refereed journal articles, invited conference papers, documented technology transfers), number of active cross-functional teams, success rate of S&T proposals, RDT&E funding level, and the workforce's participation in continuing education. The overall morale of the workforce is an intangible but important measure; this change in attitude should manifest itself in future employee opinion surveys.

E. CHAPTER SUMMARY

The three phases that comprise the development of this knowledge management initiative are discovery, prototyping, and design. Discovery is the process of understanding the requirements of the system to be designed. Prototyping is a risk mitigation effort to narrow the solution space through experimentation. Design is a creative activity that develops a physical architecture capable of performing the required functions within the cost and schedule constraints [Ref. 69].

The discovery reveals that the targeted organization's current state of knowledge management is at best ad hoc. There is no overall strategy to align the people, process, and technology to deliver the benefits of knowledge management. The reasons are many; the obvious obstacles may be inferred from the employee opinion survey (section IV.B.5). Few people know about the isolated resources (DON-CIO, NAVSEA initiatives, Technology Council, S&T Community Center, and Advanced search engines to name a few) to create a critical mass to launch a successful knowledge management initiative. Current sponsor funding structure encourages turf wars and inhibits sharing between the targeted organization and the other departments at NUWCDIVNPT. Years of decreasing funding have also reinforced the self-survival instinct of hoarding.

The scope of this KM design is kept small intentionally in order to demonstrate the return on investment quickly without a major outlay of corporate resources. The design of the IT portion is scalable such that it could be expanded to the entire organization; the corporate INTRANET infrastructure makes this possible. Insights obtained from literature review, surveys, interviews, analysis of data, and study of other

organization's knowledge management programs are used to support the KMS development. The overarching model used for this KMS design consists of intersecting people, process, and technology dimensions. Personnel training are embedded in all three of the design dimensions. Training is necessary to bring every employee to some baseline level to participate in knowledge sharing activities. Standard TCP/IP network protocol and web friendly interfaces will reduce the learning curve for most users. A grass roots effort, coupled with support from the leadership at the department level, is the proposed approach to initiate knowledge management.

Former NAVSEA commander Vice Admiral Nanos's vision is to create a new corporate strategy to provide totally integrated service to the fleet. Leadership's most important role is to nurture an environment for knowledge management activities, not to dictate the details. To paraphrase Lieutenant General Patton - Don't tell people how to do things, tell them what you want and let their ingenuity surprise you.

V. IMPLEMENTATION

A. INTRODUCTION

Knowledge management is a critical initiative to revitalize the core competency of the organization. This initiative is motivated by NAVSEA's corporate strategy to provide totally integrated service to the fleet. Implementing the proposed knowledge management initiative at the targeted organization requires a customized approach to suit its needs. A fully netted DoD acquisition management system that continually leverages the knowledge of the entire NAVSEASYS COM organization to enable its people to deliver quality services and products to the fleet is the desired end goal. This chapter discusses the implementation considerations associated with this design.

B. IMPLEMENTATION CONSIDERATIONS

Demonstrating the utility of knowledge management to the personnel at the targeted organization is the initial goal of this initiative. The proposed knowledge management system implementation for the targeted organization is a 'bottom up' design approach where the knowledge holders and seekers are involved in the entire process. Strategic goals, leadership vision, process implementation plan and capability maturity measures are discussed in the following sub-sections.

1. Strategic Goals and Leadership Vision

Knowledge Management (KM), if designed and implemented correctly, can support the many tactical and strategic decisions required in DoD acquisition management functions. For knowledge management to succeed, the work environment must be revamped to support the required changes. People do not see the need to change unless the leadership can provide a vision to inspire them. Proactive leadership from top management is necessary to emphasize the importance of KM to the organization's competitiveness. The leaders must link the KM initiative to the strategic goals of the organization. Supporting the initiative through resources is important, however, the leaders' daily actions inspire true buy-in by the intended users.

A word of caution: micro-managing the process could invite backlashes. Leaders must show their faith in their people. Developing a knowledge management culture takes time to undo old habits, uncertainties, and fears. The knowledge management system has a significant social component so it is important to encourage but not force participation.

2. Implementation Plan

The results from this study show that people play an important role in determining the fate of the knowledge management initiative. Relying too much on top down directives from management to implement Knowledge Management is usually not the best approach to get people passionately involved in the knowledge management cycle [Ref. 9, 10]. The top down approach, usually accompanied by much top management fanfare at kickoff, often does not take into account the needs of the users in terms of content, interface, accessibility, and perceived benefits. Without this involvement from the user segment, experience suggests KM will deteriorate into another management fad and become subject to apathy, if not ridicule. The leadership must also allocate sufficient funding early in the year to allow the implementation team the time and flexibility to execute the plan.

a. Implementation Team

A cross-functional implementation team should be assembled to create a knowledge map, evaluate processes, and provide support for changes. The planning activities to implement the KM initiative should include personnel representing different disciplines. It is important to invite the skeptics to participate but keep the cynics away. Donovan described the cynics as those who have quit trying but are still around the office to pull others down [Ref. 43]. Delegation of design and implementation details to the user community is essential for ensuring grass roots support of the major cultural and process changes. The team members are given the responsibility to take inventory of the current state of knowledge management activities, determine gaps, develop projects to address gaps, plan the projects, match sufficient resources with selected projects, evangelize across the department, work the plan, and monitor progress. Rotation of team

leaders (say, a 2-year term) is prudent to ensure that the knowledge management effort does not become a staff function; bringing in new blood periodically refreshes the perspective and re-energizes the process. The department's technology council should serve as consultants to the implementation team. Providing honest feedback to the leadership and to the user community is the most important function for the implementation team.

b. Redesign and Implement Organizational Processes

Some organizational re-design, based on the research results, is necessary to support knowledge management activities. The re-design addresses people, process, and technology issues that need to be resolved in order to achieve knowledge management's strategic objectives.

The Software Engineering Institute's IDEAL model provides a guide to process improvements. The acronym IDEAL stands for Initiating, Diagnosing, Establishing, Acting, and Learning. Initiating is the laying of groundwork for a successful improvement effort. Diagnosing is determining where you are relative to where you want to be. Establishing is the planning of specifics of how you will reach your destination. Acting is doing the work according to the plan. Learning is the retrospective assessment to improve the group's ability to adapt and do better in the future. [Ref. 56]

A knowledge management system adds no value if workers are unwilling to participate in the knowledge flow activities. The engineers and scientists must be encouraged and rewarded to share information with their communities of practice and become active participants. Sharing is inherently a human interaction. The re-designed reward system should emphasize teamwork versus personal heroics to encourage the knowledge sharing culture. Knowledge hoarding must not be rewarded.

All supervisors and project leaders should be trained in team building, brainstorming, information technology, and systems engineering techniques to facilitate KM activities. They should incorporate the techniques in the current tasks. In addition, supervisors should actively identify subordinates who show aptitude and develop them to

serve on the implementation team. Management's job is to remove obstacles and let the people excel in a nurturing knowledge-based environment.

c. Pilot KM Projects

Because of the resource constraints, it may be necessary to divide the plan for the knowledge management initiative into a series of iterative steps (or projects). A spiral or iterative implementation approach permits lessons learned, best practices, and new requirements to be incorporated. It is imperative for the implementation team to carefully select a handful of pilot projects to demonstrate the benefits of knowledge management quickly. These early successes will help attract funding from the programs to support the targeted organization's knowledge management effort as a part of its infrastructure. The expected time to see tangible results should be about a year from program initiation [Ref. 10, 45]. Public affairs efforts to trumpet the benefits of knowledge sharing are necessary to maintain the initiative's visibility. The pilot projects should address high priority department issues so that the successes are rapidly beneficial to the organization. Getting sponsor participation would be extremely important since they would experience first hand the targeted organization's knowledge management successes. The objective is for the sponsors to consider the organization as the preferred place to do business because of its effective leveraging of the community's intellectual capital.

The selected KM projects should be balanced among the people, process, and technology dimensions and management needs to be supported with sufficient resources. They should be designed as building blocks within the context of the organization's desired state. Additional resources should be allocated to champion knowledge flow activities such as journal paper publications (preferably joint authorship), conference participation, lecture series (by in-house and invited speakers), information technology upgrades, and knowledge management training.

d. Technology Selection

Technology makes many knowledge management projects possible but it plays a support role to the total system implementation. There are, however, many information technology tools being hawked by vendors that could end up being 'shelf ware' if we just want to buy a turnkey KM solution. It is more important to leverage the currently deployed IT tools and map their capabilities to the organization's KM project requirements. From the discovery phase results, it is observed that most people use only a small portion of the capabilities in their software products. The information technology tools that support the knowledge management initiative must not be proprietary solutions. Commercial off the shelf hardware and software should be mandated such that the targeted organization remains compatible with the NAVSEA corporate organization and the rest of DoD. This is not to say that specific brands of computers, software packages, and system integrators should be used. The goal is to maintain compatibility through the use of open system architecture design in building the knowledge management IT infrastructure. The design must be scaleable and compatible such that this pilot program can be used as a template to propagate knowledge management throughout the entire NAVSEA organization without major re-design of the IT tools.

e. Project Management

Knowledge management projects should be managed as all other projects. Each project should have a plan detailing the objective(s), schedule, key personnel assignment, resource requirements, milestones, and deliverables. Risk assessment and a risk mitigation plan should be prepared and evaluated by peers to improve the success rate. The KM project leaders must be aware of the impediments and devise ways to mitigate their effects on the KM progress.

3. Capability Maturity Measures

Carnegie Mellon Software Engineering Institute (SEI) has developed the SEI Capability Maturity Model (CMM) to assess the work practice maturity of software development [Ref. 74]. Work practice maturity is assessed in four areas. They are

processes, people, technology, and measurement. Figure 17 shows the implications of advancing an organization through the capability maturity model. The targeted organization should set goals for its knowledge management initiative to progress through similar maturity levels.

Implications of Advancing Through CMM Levels.					
	Level 1	Level 2	Level 3	Level 4	Level 5
Processes	Few stable processes exist or are used.	Documented and stable estimating, planning, and commitment processes are at the project level.	Integrated management and engineering processes are used across the organization.	Processes are quantitatively understood and stabilized.	Processes are continuously and systematically improved.
	"Just do it"	Problems are recognized and corrected as they occur.	Problems are anticipated and prevented, or their impacts are minimized.	Sources of individual problems are understood and eliminated.	Common sources of problems are understood and eliminated.
People	Success depends on individual heroics.	Success depends on individuals; management system supports.	Project groups work together, perhaps as an integrated product team.	Strong sense of teamwork exists within each project.	Strong sense of teamwork exists across the organization
	"Firefighting" is a way of life.	Commitments are understood and managed.	Training is planned and provided according to roles.		Everyone is involved in process improvement.
	Relationships between disciplines are uncoordinated, perhaps even adversarial.	People are trained.			
Technology	Introduction of new technology is risky.	Technology supports established, stable activities.	New technologies are evaluated on a qualitative basis.	New technologies are evaluated on a quantitative basis.	New technologies are proactively pursued and deployed.
Measurement	Data collection and analysis is ad hoc.	Planning and management data used by individual projects.	Data are collected and used in all defined processes.	Data definition and collection are standardized across the organization.	Data are used to evaluate and select process improvements.
			Data are systematically shared across projects.	Data are used to understand the process quantitatively and stabilize it.	

Figure 17. Implications of Advancing Through the Capability Maturity Model [from Ref. 74]

C. SUMMARY

Any process improvement program should be driven by and related to a well defined set of organizational needs. By considering change drivers in the context of the organization's strategic objectives one can develop a vision of the desired state, what the organization should look like, and how it should behave after the changes are implemented. [Ref. 56]

It is important for leaders to align the organization for the knowledge management initiative since it involves significant changes to the status quo. Top management must make KM a priority, support the project with sufficient resources, and staff the project with interested users. An empowered implementation team should guide the planning, select projects, and manage the projects. A large amount of industry-reported data indicates that Capability Maturity Model (CMM) based process improvements are beneficial and have significant return on investment [Ref. 56]. Process improvement performance of the targeted organization's knowledge management initiative can be assessed using the CMM with some customization to suit its strategic objectives.

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VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

Knowledge management is a critical initiative to revitalize the core competency of an organization. Core competencies, rather than core products, are the enduring differentiators to separate the successful companies from the also-rans [Ref. 10, 16-20].

This thesis research focuses on the knowledge management needs of a specific Department of Defense (DoD) organization and the subsequent process redesign to improve its knowledge-management (KM) capabilities. It is anticipated that applying knowledge management concepts to the targeted organization would improve its efficiency and enhance its core competency. The initial goal is to enable the organization to gain a competitive advantage in its areas of excellence with the long-term goal of expanding the KM initiative across the entire enterprise in order to maximize the global operating efficiency. A fully integrated DoD knowledge management system that continually leverages the intellectual capital of the entire enterprise to consistently deliver quality services and products is the desired end goal.

The development of the knowledge management system utilizes a systematic approach. It begins with an in-depth discovery phase to understand the organization's needs and derive system requirements followed by prototyping activities to evaluate possible solutions. Finally, a knowledge management system design is proposed using the results from the discovery and prototyping phases. Implementing the proposed knowledge management initiative at the targeted organization requires a customized approach to suit its needs. A revamped people, process, and technology framework is designed to allow the targeted organization to excel not only in its core competency but also in exploring new opportunities.

Leaders must create a work environment for people to collaborate and share knowledge. An optimal process improvement effort balances the people, process, and technology dimensions to guide the organization to the desired state. The return on investment from knowledge management is the realization and sustainability of a performance driven organization.

Knowledge Management is here to stay; it may be called something else in the future but its premise is so fundamental that it must be incorporated into standard operating procedures of successful organizations. Leveraging the intellectual capital of the entire organization instead of working as individuals is the only way to gain a competitive advantage.

Two major conclusions emerge from this research. Firstly, for knowledge management to succeed, an organization must articulate its strategic business needs, create a common framework for understanding, secure employee buy-in, and maintain open communications. Secondly, an optimal knowledge management system design must take into account the user's perspective since efficient knowledge flow and knowledge transformations depend on people's willing participation.

B. RECOMMENDATIONS FOR THE TARGETED ORGANIZATION

The management of the targeted organization has shown interest in knowledge management. Some actions may be taken readily to maintain the momentum initiated by the Technology Council. The first order of business is for the leadership to articulate and share the vision with the entire department, explaining in concise terms the linkage of knowledge management to the organization's strategic objectives. Management should then support the labor cost of the core knowledge management team to complete the detailed design and develop the implementation plan of the KMS. User involvement in the development is essential to secure buy-in; therefore, the team must be vigilant in involving users in the process. It may be easier to "Just Do It" with a few senior staff members. However, without the user-developer interactions the initiative would not stand a chance of meeting user expectations. Management can demonstrate its support of knowledge management in action by populating its program manager's folders as soon as the bi-weekly meeting is adjourned. This can be accomplished easily by requiring electronic submission of reports to the department head prior to each meeting. Updates and/or modifications may be entered during the meeting to ensure the reports' correctness. Likewise, external presentations and documents should be posted on the INTRANET since they have already been peer reviewed. This alone would alleviate a lot

of the frustration (and wasted time) of finding the people from whom the documents/presentations originated. As mentioned previously, the IT administrator has set up a file structure to accept the content; he is just waiting for submissions. A training program on currently deployed IT tools should be included in the employees' training requirements to achieve baseline competence to exploit the full capabilities of the existing tools. Lastly, the brown bag seminars and core competency lectures series should receive management support since they provide excellent opportunities to exchange ideas. Regular attendance by managers would indicate the importance of these events toward achieving the department's knowledge management objectives.

C. RECOMMENDATIONS FOR FUTURE RESEARCH

Several recommendations for future research to further expand our understanding of knowledge management are presented in this section.

1. Design Survey

Feedback from the users is an important mechanism to use in fine-tuning the knowledge management system. A follow-on effort would be to design questions related to different factors of knowledge management into the next command-wide employee opinion survey. Similar questions may be designed for the sponsor (customer) survey. An analysis framework design should be part of this research to ensure that the measurements support the analysis to yield the information needed for KM system tuning.

2. Design a Knowledge Management Awareness Program

A shared vision requires the participants to have attained a certain level awareness. A follow-on research is to design an awareness program for the acquisition management workforce in order to shape the sharing culture, understand KM concepts, and use KM tools. A similar knowledge management indoctrination program may be designed to bring new employees to a contributory level quicker.

3. Link the Knowledge Flow with Organizational Performance

The efficiency of knowledge flow through an organization is used as a measure of knowledge management capability. How do knowledge flows differ among organizations with different scopes of work? A research laboratory should have very different knowledge flow needs than a trucking company. How do we account for the work scope difference to design suitable knowledge management systems using a generalized framework?

4. Define Supply and Demand Function for Knowledge Sharing

Knowledge sharing requires at least two parties to participate, a knowledge seeker and a knowledge provider. This transaction may be recast as a supply and demand function in which knowledge sharing occurs when the transaction price is satisfactory to both parties. The derivation of a functional relationship will help determine the optimal price ranges (pay, recognition, other benefits) for knowledge management system designs.

5. Measure the Performance Metrics

Are the current knowledge management performance metrics to quantify KM's return on investment measuring the right things? That is, if we maximize the metrics do we also maximize the bottom line results that we seek? How do we design relevant metrics for different organizations?

APPENDIX A. STATISTICAL ANALYSIS OF AN IPT SURVEY

A. INTRODUCTION

Between November and December 2000, a group of nine PD-21 students conducted a study on the use and effectiveness of Integrated Product Teams in NAVSEA and NAVAIR acquisition, research and development organizations. Forty-Nine federal employees responded to surveys and a majority of this sample participated in follow-up interviews. The narrative and quantitative results were analyzed against a list of sixteen hypotheses. Some very interesting relationships among the respondents' assessment of integrated process team (IPT) effectiveness, person's perceived power, organizations, and type of work were discovered that might be useful to understand the team dynamics aspect of collaboration. This study on IPTs has direct application to the design of a knowledge management system in the targeted organization.

B. DESCRIPTION OF SURVEY

The PD-21 team east (nine members from NAVSEA and NAVAIR commands) converged on a questionnaire in early November 2000 to collect data for the study. The survey questions designed by the PD-21 east coast team are shown in Figure 18.

Each team member conducted an average of five (5) surveys and a lesser number of follow up interviews to support the study. Oral interviews were used whenever possible in order to capture the non-verbal clues.

Forty-nine surveys were completed with 25 of the interviewees drawn from the NAVAIR organization and 24 from the NAVSEA organization. One person at each organization reported their experiences in distinct IPTs and their inputs were tabulated as two entries resulting in a total sample size of 51. Twenty-five individuals reported fewer than or equal to five years of IPT experience, nineteen reports between five and ten years and seven reported having over ten years of experience. The median IPT experience was six years.

Name		
Position		
Background		
What level of IPT do you usually work in? (Multi-platform overarching IPT, Platform-wide IPT, System IPT (e.g., propeller, engine), Subsystem IPT, or other.)		
ASK THE FOLLOWING CORE QUESTIONS:		ANSWER
1.	a) How many years experience have you had with IPT-like teams?	
	b) What has been your role(s) on IPT-like teams?	
2.	How would you rate your organization's overall effectiveness in building and managing successful IPTs (1=outstanding through 5=poor)	
3.	How common is the use of IPTs in your organization? (1=very common, 2=significant, 3=moderate, 4=limited, 5=nonexistent)	
4.	Do you feel your organization has accepted the concept of IPTs and team building as an effective and efficient means of executing programs and developing initiatives? (1=yes, 2=not sure, 3=no)	
5.	Does your Command have a <i>Team Building Guide</i> to facilitate successful IPTs? (1=yes, 2=not sure, 3=no)	
6.	Does your Command have a recommended or required IPT training program for building successful teams? (1=yes, 2=not sure, 3=no)	
7.	Describe a good IPT experience you have worked on and why you feel it worked? <i>(The interviewer should elicit comments on cultural, political, and strategic aspects, as well as how people's needs were met)</i>	
8.	Describe a marginal or poor IPT that have worked on and why you think it did not work well? <i>(The interviewer should elicit comments on cultural, political, and strategic aspects, as well as how people's needs were met)</i>	
9.	What would you change about IPTs if you could?	
10.	Where do you think IPTs should go in the future?	

Figure 18. Survey Form Used for the PD-21 Excellency in IPT Study [from Ref. 60]

C. STATISTICAL ANALYSIS

Categorical data is collected from the responses to survey questions 1 through 6. The interviewee's relative power level in his/her organization and his/her personal endorsement of IPT in general are derived from the narrative questions and interviewers' notes. The attributes extracted from the survey answers and interviews are:

- IPT Experience and role
- Type of Work (Research, Development, Test, and Evaluation (RDT&E), Science and Technology (S&T), In Service Engineering (ISE), and others)
- Organization: NAVSEA or NAVAIR
- Personal power level (Position, experience, IPT role)
- Personal rating of own IPT effectiveness
- Usage of IPT
- Organizational commitment (training)
- Personal assessment of IPTs in general

The following is a description of the Chi-square test of independence.

H₀, Null hypothesis: The two variables are independent.

H₁, Alternative hypothesis: The two variables are dependent.

The Chi-Square Test statistics is given by the expression:

$$\chi^2 = \sum_i \sum_j \left[\frac{(n_{ij} - E_{ij})^2}{E_{ij}} \right]$$

$$E_{ij} = \frac{(\text{row } i \text{ total})(\text{column } j \text{ total})}{n}$$

Rejection region: Reject **H₀** if Chi-Square exceeds value of chi-square for the desired error value of α and degrees of freedom (df). That is, reject the null hypothesis **H₀** if

$$\chi^2 > \chi^2_{\alpha}(df)$$

where

$$df = (r-1)(c-1)$$

r = number of rows in the table

c = number of columns in the table

E_{ij} = expected number of measurements falling in the i, j cell (i^{th} row and j^{th} column) when the two variable are assumed to be independent.

n_{ij} = actual number of measurements falling in the i, j cell (i^{th} row and j^{th} column)

row_i_total = sum of all entries in row i

column_j_total = sum of all entries in column j

n = sum of all rows or sum of columns (i.e., the sample size)

The statistical analysis of the IPT survey data is performed by testing hypothesis to determine the dependence between paired attributes. For example, one may want to test the hypothesis that success of IPT is independent of the organizations, politics or culture. Three main areas are identified for analysis:

- IPT implementation and assessment between NAVSEA and NAVAIR
- Assessment of IPTs from the Political and Cultural Perspectives
- Assessment of IPTs as a Function of Team Experience

A total of sixteen hypotheses are constructed for this analysis. The Pearson Chi-squares statistics is used to test the association between categories and attributes in the contingency tables. The rejection criterion is set at $\alpha = 0.05$ (or 5%) level meaning that the error of rejection the hypothesis is 5% when the hypothesis is indeed true.

1. IPT Implementation and Assessment Between NAVSEA and NAVAIR

Hypothesis 1: NAVSEA and NAVAIR personnel have similar assessment on IPTs. Table 9 shows the distribution of positive and negative views.

Table 9. Personal IPT Assessment

	Positive on IPT	Neutral	Negative on IPT
NAVSEA	14	8	3
NAVAIR	12	12	2

Chi-squares = 1.14, df=2, Rejection level = 5.99

Analysis 1: Since the chi-squares is less than the rejection level, the hypothesis is accepted at the 0.05 level, that is, both NAVSEA and NAVAIR personnel have similar assessment on their IPTs. A majority of personnel from NAVSEA and NAVAIR are positive about their organizations' IPT implementation and feel that they should be continued.

Hypothesis 2: NAVSEA and NAVAIR personnel rate their organizations' IPT effectiveness similarly. The results are shown in Table 10.

Table 10. Interviewee's assessment of his/her organization's IPTs

	1 (out-standing)	2	3	4	5 (poor)
NAVSEA	4	7	8	5	1
NAVAIR	3	8	11	4	0

Chi-squares = 1.78, df=4, Rejection level = 9.49

Analysis 2: Hypothesis is accepted at the 0.05 level. However, the interviewees' assessment of their organizations' IPT effectiveness is lukewarm with the assessment clustered at the '3' ranking.

Hypothesis 3: IPTs are common in both organizations. Table 11 tabulates the IPT usage in both organizations.

Table 11. Interviewee's assessment of his/her organization's IPT usage

	1 (frequent)	2	3	4	5 (non-existent)
NAVSEA	10	5	3	6	1
NAVAIR	20	5	1	0	0

Chi-squares = 11.32, df=4, Rejection level = 9.49

Analysis 3: In this case, the chi-squares is greater than the rejection level. The Hypothesis is rejected at the 0.05 level. That is, NAVAIR uses IPTs more often.

Hypothesis 4: IPTs are accepted in both organizations. Table 12 tabulates the IPT acceptance in both organizations.

Table 12. Interviewee's assessment of his/her organization's acceptance of IPT

	1 (YES)	2 (not sure)	3 (NO)
NAVSEA	19	4	2
NAVAIR	20	4	2

Chi-squares = 0.006, df=2, Rejection level = 5.99

Analysis 4: Hypothesis is accepted at the 0.05 level. Both organizations have similar acceptance of IPTs.

Hypothesis 5: Both organizations are aware of Team Building Guide to facilitate IPTs. Table 13 tabulates the interviewees' awareness of Team Building Guide in their organizations.

Table 13. Awareness of Team Building Guide

	1 (YES)	2 (not sure)	3 (NO)
NAVSEA	3	17	5
NAVAIR	10	12	4

Chi-squares = 4.72, df=2, Rejection level = 5.99

Analysis 5: Hypothesis is accepted at the 0.05 level. However, NAVAIR is more aware of Team Building Guide if only the definite 'yes' and 'no' answers are considered. The majority of both organizations are not aware of any guidance though.

Hypothesis 6: Both organizations are equally aware of formal training to facilitate IPTs. Table 14 tabulates the interviewees' awareness of IPT training in their organizations.

Table 14. Awareness of IPT training

	1 (YES)	2 (not sure)	3 (NO)
NAVSEA	9	10	6
NAVAIR	12	6	8

Chi-squares = 1.70, df=2, Rejection level = 5.99

Analysis 6: Hypothesis is accepted at the 0.05 level. However, the majority of the interviewees are not aware of IPT training.

2. Assessment of IPTs from the Political and Cultural Perspectives

Hypothesis 7: Assessment of IPT success is independent of the interviewee's real or perceived power. Table 15 tabulates the assessment of IPT with the interviewee's power base as a parameter.

Table 15. Interviewee's assessment of his/her organization's IPTs

	1 (out-standing)	2	3	4	5 (poor)
Power	5	9	4	2	0
~Power	2	6	15	7	1

Chi-squares = 10.13, df=4, Rejection level = 9.49

Analysis 7: Hypothesis is rejected at the 0.05 level. The more powerful personnel are more favorable toward IPTs than the less powerful (~Power).

Hypothesis 8: Perceived acceptance of IPT in own organization is independent of the interviewee's real or perceived power. Table 16 tabulates the organization's acceptance of IPTs with the interviewee's power base as a parameter.

Table 16. Interviewee's assessment of his/her organization's acceptance of IPTs

	1 (YES)	2 (not sure)	3 (NO)
Power	18	1	1
~Power	21	7	3

Chi-squares = 3.52, df=2, p-value = 5.99

Analysis 8: Hypothesis is accepted at the 0.05 level. The perceived acceptance of IPT in own organization is independent of the interviewee's real or perceived power.

Hypothesis 9: Awareness of organization's Team Building Guide is independent of the interviewee's real or perceived power. Table 17 tabulates the awareness of Guide with the interviewee's power base as a parameter.

Table 17. Interviewee's awareness of his/her organization's guide to IPT

	1 (YES)	2 (not sure)	3 (NO)
Power	5	12	3
~Power	8	17	6

Chi-squares = 0.19, df=2, Rejection level = 5.99

Analysis 9: Hypothesis is accepted at the 0.05 level. The awareness of organization's Team Building Guide is independent of the interviewee's real or perceived power. The more interesting result is that most people are not aware of their organizations' team building guides (every organization in the survey has an official team building guide).

Hypothesis 10: Awareness of organization's IPT training is independent of the interviewee's real or perceived power. Table 18 tabulates the awareness of IPT training with the interviewee's power base as a parameter.

Table 18. Interviewee's awareness of his/her organization's IPT training

	1 (YES)	2 (not sure)	3 (NO)
Power	10	3	7
~Power	11	13	7

Chi-squares = 4.12, df=2, Rejection level = 5.99

Analysis 10: Hypothesis is accepted at the 0.05 level. In general, the less powerful (~Power) are not as aware as the powerful about the existence of Team Building Guide and IPT training opportunities.

Hypothesis 11: Personal assessment on IPT is independent of the interviewee's real or perceived power. Table 19 tabulates the interviewees' personal assessments.

Table 19. Personal IPT Assessment

	Positive on IPT	Neutral	Negative on IPT
Power	13	7	0
~Power	13	13	5

Chi-squares = 4.64, df=2, Rejection level = 5.99

Analysis 11: Hypothesis is accepted at the 0.05 level. The less powerful (~Power) and the more powerful assess IPTs similarly. However, all the negative votes came from the less powerful group.

3. Assessment of IPTs as a Function of Team Experience

Hypothesis 12: Personal assessment on IPT is independent of the interviewee's years of IPT experience. Table 20 tabulates the interviewees' personal assessments vs. experience.

Table 20. Personal IPT Assessment

	Positive on IPT	Neutral	Negative on IPT
Years <= 5	13	9	3
5 < years <= 10	8	10	1
Years > 10	5	1	1

Chi-squares = 3.59, df=4, Rejection level = 9.49

Analysis 12: Hypothesis is accepted at the 0.05 level. The interviewees' personal IPT assessment is independent of years of IPT experience. People do not appear to get cynical with years.

Hypothesis 13: Assessment on own IPT is independent of the interviewee's years of IPT experience. Table 21 tabulates the interviewees' assessments on their organization's IPT vs. own experience.

Table 21. Assessment of own IPT Success by experience

	1 (out-standing)	2	3	4	5 (poor)
Years <= 5	2	7	11	4	1
5 < years <= 10	4	6	5	4	0
Years > 10	1	2	3	1	0

Chi-squares = 3.61, df=8, Rejection level = 15.51

Analysis 13: Hypothesis is accepted at the 0.05 level. Interviewees' assessment on own IPT's success is independent of years of IPT experience. People do not appear to get discouraged with years.

Hypothesis 14: Assessment on own IPT is independent of the interviewee's type of work. Table 22 tabulates the interviewees' assessments on their organization's IPT vs. work type.

Table 22. Assessment of own IPT Success by work type

	1 (out-standing)	2	3	4	5 (poor)
S&T/ RDT&E	5	7	9	8	1
ISE/ Other	2	8	10	1	0

Chi-squares = 6.46, df=4, Rejection level = 9.49

Analysis 14: Hypothesis is accepted at the 0.05 level. Interviewees' assessment on own IPT's success is independent of their type of work. Regrouping the rankings into two groups [1+2+3] and [4+5] yields table 23. This new grouping shows there are

significantly more negative assessments regarding own IPT success in the S&T and RDT&E work forces.

Table 23. Combined assessment of own IPT success

	[1+2+3]	[4+5]
S&T/ RDT&E	21	9
ISE/ Other	20	1

Chi-squares = 4.99, df=1, Rejection level = 3.84

The new groupings shows that the interviewees in the S&T and RDT&E community are more likely to rate their organizations' IPT to be less successful than the ISE samples.

Hypothesis 15: Personal assessment on IPT is independent of the interviewee's type of work. Table 24 tabulates the interviewees' assessments on IPT vs. work types.

Table 24. Personal Assessment on IPT by Work Types

	Positive on IPT	Neutral	Negative on IPT
S&T/ RDT&E	14	11	5
ISE/ Other	12	9	0

Chi-squares = 3.89, df=2, Rejection level = 5.99

Analysis 15: Hypothesis is accepted at the 0.05 level. The interviewees' assessment IPT is independent of their type of work. However, in conjunction with analysis 14 one may infer that interviewees in the S&T and RDT&E do not view IPTs as favorably as their ISE counterparts.

Hypothesis 16: Usage of IPTs is independent of the real or perceived power. Table 25 tabulates the IPT usage as reported by the powerful and less powerful (~Power).

Table 25. Interviewee's assessment of his/her organization's IPT usage

	1 (frequent)	2	3	4	5 (non- existent)
Power	12	5	1	2	0
~Power	18	5	3	4	1

Chi-squares = 1.54, df=4, Rejection level = 9.49

Analysis 16: Hypothesis is accepted at the 0.05 level. The reported frequency of IPT usage is independent of the interviewees' real or perceived power.

D. SUMMARY OF ANALYSIS RESULTS

Training is generally not available to prepare people to work in team settings. The analysis results indicate that the leaders have not done the necessary preparations prior to deploying IPTs in their organizations. The personal awareness of training guides and resources is low in both NAVSEA and NAVAIR organizations. NAVAIR's personnel appear to have more IPT exposures.

Those in power (position and/or technical) favor IPT since they have the training and time to participate in IPTs. There is also a vested interest for management to support a management initiative.

People in RDT&E do not favor IPT as much as those in logistics. This is understandable since the engineers and scientists are more likely to be introverts.

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APPENDIX B. SURVEY QUESTIONS USED TO ASSESS THE TARGETED ORGANIZATION'S KNOWLEDGE MANAGEMENT STATUS

Table 26. Questions for KM Specific Survey

Questions
1. How do you find out about other people's technical work in the department that may help your project?
2. Do you consider yourself as an information or knowledge source for the department?
3. Do you attend the technical presentations organized by the various departments?
4. Are you participating in the department's and/or the center's mentoring program?
5. Do you have an informal mentoring arrangement?
6. Do you feel that the senior staff members are willing to take time to share with new hires?
7. Have you found useful information in the code 34 intranet that is useful in your work?
8. Have you found useful information in the NUWC intranet net that is useful in your work?
9. What internet/intranet tools do you use to find information?
10. How effective are the computer based collaborative tools you use to work with your technical team? (e.g. email, lotus notes, instant messenger)
11. How often do you participate in on-line discussion bulletin boards?
12. Do we feel that the department has a knowledge sharing culture? Cite examples.
13. Do you feel that there is sufficient leadership support for information and knowledge sharing across the center's product line?
14. What steps should the department take to encourage cross- functional sharing of knowledge?

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